

16-720B Homework 3 Write-up

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October 20, 2019

Q1.1

- $\frac{\partial \mathcal{W}(\mathbf{x}; \mathbf{p})}{\partial \mathbf{p}^T}$ is the graident of the warped coordinates over the warping parameter \mathbf{p} , which is:

$$\frac{\partial \mathcal{W}(\mathbf{x}; \mathbf{p})}{\partial \mathbf{p}^T} = \frac{\partial \mathbf{x} + \mathbf{p}}{\partial \mathbf{p}^T} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}. \quad (1)$$

- For the iterative process, replace \mathbf{p} with $\mathbf{p} + \Delta \mathbf{p}$ in Eq. (2) of the handout, and then

$$\mathcal{I}_{t+1}(\mathbf{x} + \mathbf{p} + \Delta \mathbf{p}) - \mathcal{I}_t(\mathbf{x}) = \mathcal{I}_{t+1}(\mathbf{x} + \mathbf{p}) + \frac{\partial \mathcal{I}_{t+1}(\mathbf{x} + \mathbf{p})}{\partial (\mathbf{x} + \mathbf{p})^T} \Delta \mathbf{p} - \mathcal{I}_t(\mathbf{x}) \quad (2)$$

$$= \nabla \mathcal{I}_{t+1}(\mathbf{x} + \mathbf{p}) \Delta \mathbf{p} - (\mathcal{I}_t(\mathbf{x}) - \mathcal{I}_{t+1}(\mathbf{x} + \mathbf{p})). \quad (3)$$

Therefore the Eq. 2 of the handout in vector form is (Note that each $\nabla \mathcal{I}_{t+1}(\mathbf{x} + \mathbf{p})$ are of shape 1×2 .)

$$\arg \min_{\Delta \mathbf{p}} \left\| \begin{bmatrix} \nabla \mathcal{I}_{t+1}(\mathbf{x}_1 + \mathbf{p}) \\ \nabla \mathcal{I}_{t+1}(\mathbf{x}_2 + \mathbf{p}) \\ \dots \\ \nabla \mathcal{I}_{t+1}(\mathbf{x}_D + \mathbf{p}) \end{bmatrix} \Delta \mathbf{p} - \begin{bmatrix} \mathcal{I}_t(\mathbf{x}_1) - \mathcal{I}_{t+1}(\mathbf{x}_1 + \mathbf{p}) \\ \mathcal{I}_t(\mathbf{x}_2) - \mathcal{I}_{t+1}(\mathbf{x}_2 + \mathbf{p}) \\ \dots \\ \mathcal{I}_t(\mathbf{x}_D) - \mathcal{I}_{t+1}(\mathbf{x}_D + \mathbf{p}) \end{bmatrix} \right\| = \arg \min_{\Delta \mathbf{p}} \|\mathbf{A} \Delta \mathbf{p} - \mathbf{b}\| \quad (4)$$

The big matrix and the big vector on the L.H.S. of the above equation are the \mathbf{A} and \mathbf{b} .

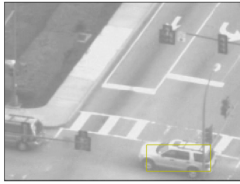
- To solve for the least square solution of Eq. 4, we need to compute $(\mathbf{A}^T \mathbf{A})^{-1} \mathbf{A}^T \mathbf{b}$. Therefore, we must have $\mathbf{A}^T \mathbf{A}$ to be invertible.

Q1.3

Please find the results of Lucas-Kanade tracking results in Figure. 1



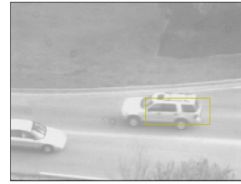
(a) frame 1



(b) frame 100



(c) frame 200



(d) frame 300



(e) frame 400

Figure 1: Lucas-Kanade Tracking Results with One Single Template.

Q1.4

Please find the results from Lucas-Kanade Tracking with template correction in Figure. 2, with the comparison to that without template update. We can clearly see that the tracking with template correction yields a better result for late frames.

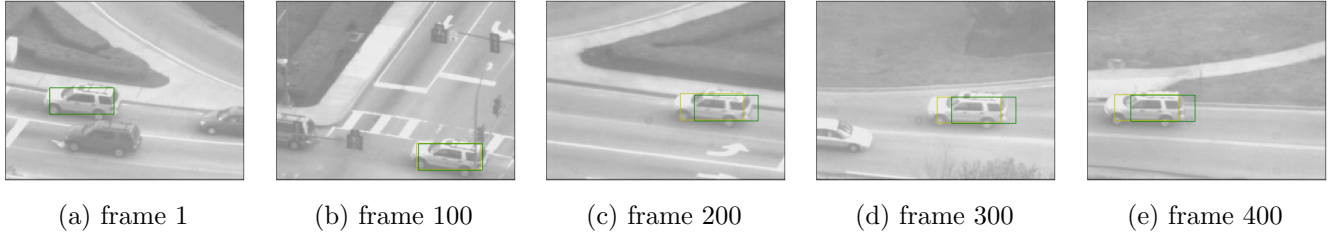


Figure 2: Lucas-Kanade Tracking Results with Template Correction (in yellow boxes). The performance of the baseline tracker in **Q1.3** is in green boxes.