Computer Vision
Assignment 3 Part 2

Object Tracking in Videos

Using
Lucas-Kanade: Forward Additive Alignment

Prepared By:

Eman Mohamed Salah El-Din	6072
Nael Mostafa Mohamed	6099
Ahmad Abdelrahman Marouf	6543

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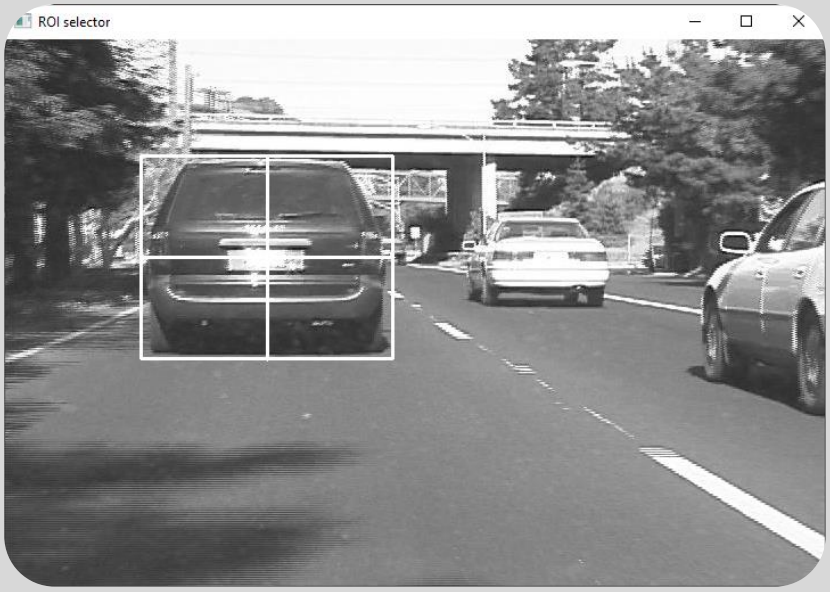
1. Implementation

1.1 Selecting ROI

We use cv2.selectROI() function which pops up a window of the first frame in the video and lets the user draw a rectangle around the object they wish to track.



The output of the function is a rectangle represented as the array [x, y, w, h] where (x, y) are the coordinates of the top left corner and (w, h) are the width and height of the rectangle.

1.2 Objective

p: parameters of affine transformation

Estimate the values of $\boldsymbol{p}$ by iteratively computing and adding $\Delta \boldsymbol{p}$. which warps **a template frame** into **the current frame** such that the 'Loss' between them is minimum. We stop when $\Delta \boldsymbol{p}$ is below a certain threshold.

$$L = \sum_{x} [T(x) - I(W(x; p + \Delta p))]^2$$

1.3 Procedure

1. Flatten ROI's pixels into a 1D array instead of 2D

2. Initialize affine transform parameters $\boldsymbol{p}$ to zeros

3. Compute warp matrix $\boldsymbol{W(p)}$ using as:

$$W(p) = \begin{bmatrix} 1+p_1 & p_3 & p_5 \\ p_2 & 1+p_4 & p_6 \\ 0 & 0 & 1 \end{bmatrix}$$

4. Warp template points using the warp matrix. Get pixel values in current frame corresponding to warped points. Then compute the difference between the template intensities and warped intensities as $\boldsymbol{b}$.

$$b = T(x) - I(W(x;p))]$$

5. Compute image horizontal and vertical gradients for the unrolled warped image points to get $\boldsymbol{\Delta I(x) = [\frac{dI(x)}{du}, \frac{dI(x)}{dv}]}$

6. Compute the Jacobian matrix of the affine warp using the x and y coordinates of the selected ROI points as follows:

$$\frac{\partial W}{\partial p} = \begin{pmatrix} x & 0 & y & 0 & 1 & 0 \\ 0 & x & 0 & y & 0 & 1 \end{pmatrix}$$

7. Multiply Jacobian and Image gradient to get matrix $\boldsymbol{A}$

$$A = \sum_{x} [\Delta I(x) \frac{\mathrm{d}W}{\mathrm{d}p}]$$

8. Compute Hessian matrix:

$$(A^T A) = H = \sum_{x} [\Delta I(x) \frac{\mathrm{d}W}{\mathrm{d}p}]^T [\Delta I(x) \frac{\mathrm{d}W}{\mathrm{d}p}]$$

9. Calculate $\Delta \boldsymbol{p}$ using:

$$\Delta p^* = (A^T A)^{-1} A^T b$$

If $\Delta \boldsymbol{p}$ is more than the set threshold, additively update $\boldsymbol{p}$ and repeat steps 3-9. Otherwise return $\boldsymbol{p}$.

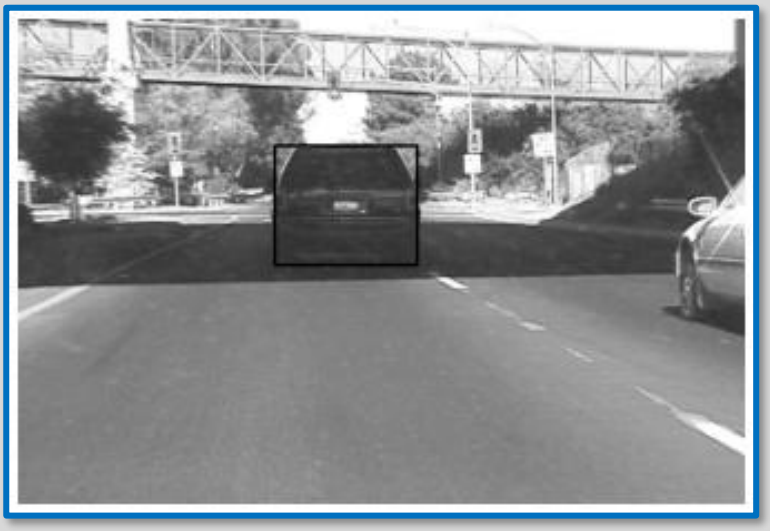
2. Results

Results are provided as GIFs with the submitted files.

2.1 Car 1:

Frame 1

Frame 170



Frame 250

2.2 Car 2:

Frame 1

Frame 200

Frame 400

2.3 Landing:

Frame 1

Frame 20

Frame 45