Vehicle Speed Estimation Using Computer Vision And Evolutionary Camera Calibration

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Introduction

This work introduces an evolutionary approach for homography estimation [1] to calibrate fixed-point cameras [2] on the road and estimate vehicle speed using object tracking.

$$s\begin{pmatrix}x'\\y'\\1\end{pmatrix}=\mathbf{H}\begin{pmatrix}x\\y\\1\end{pmatrix}=\begin{pmatrix}h_{11}&h_{12}&h_{13}\\h_{21}&h_{22}&h_{23}\\h_{31}&h_{32}&h_{33}\end{pmatrix}\begin{pmatrix}x\\y\\1\end{pmatrix}$$

Methodology

Video Dataset
- 10 scenes
- 25 fps
- ~8-10 min
- world/image point correspondences

Performance metrics:
- Homography: projection Error (estimation of image points from world points)

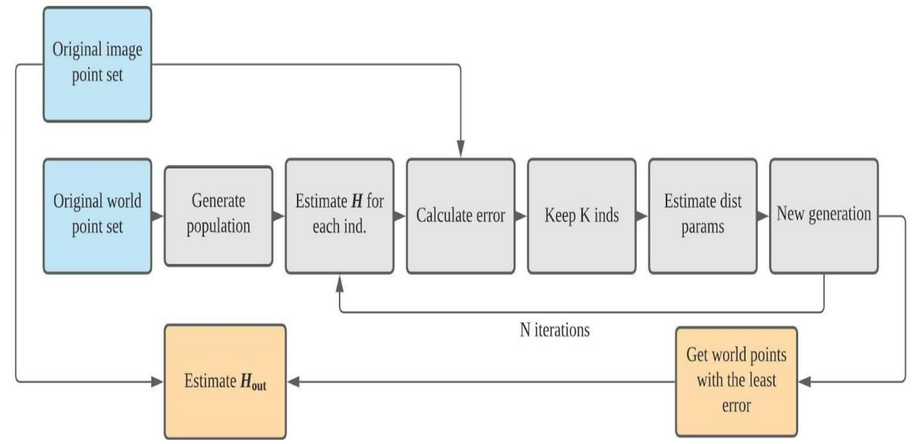
$$\epsilon=\frac{1}{n}\sum_{i=1}^{n}||x_i'-\hat{x_i'}||_2,$$

- Speed estimation: distributions of speed for each video

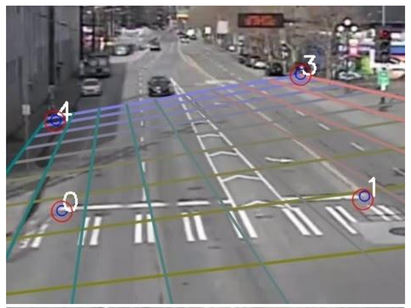
Homography estimation
1. DLT
2. RANSAC [3] DLT
3. Evolutionary [4] DLT

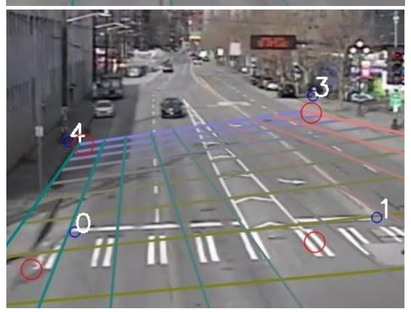
Object Detection
1. YOLOv4 [5]

Object tracking [6] and speed
1. IoU



Results

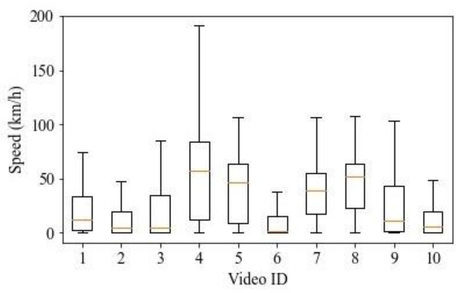




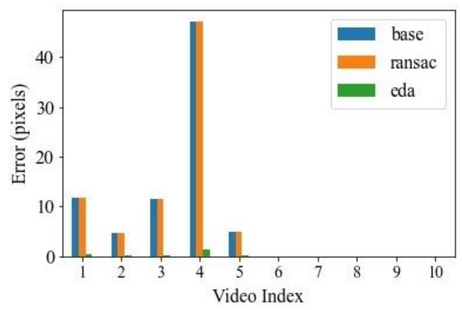
Graphical comparison of the calibrations

Proposed evolutionary DLT

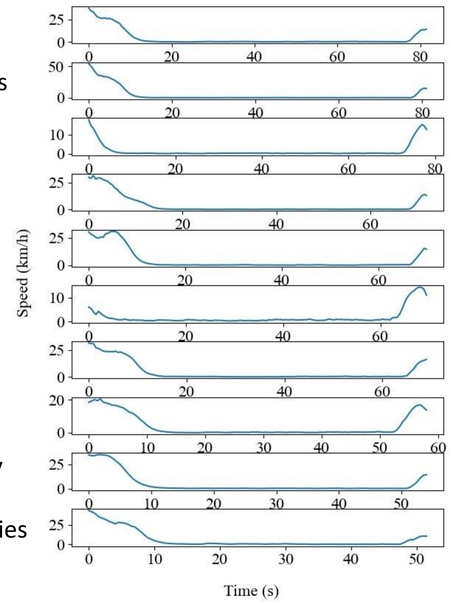
Base DLT



Distributions of speed for all the videos



Projection error for the evaluated homography estimation methodologies



Independent speed timeseries from video 7 for 10 vehicles

Conclusions

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1. Both RANSAC and base algorithms got an error of 7.99 pixels, while the proposed returned only 0.24. This represents a reduction of 97% in projection error.
2. Most speed values are less than 70 km/h. The speed estimation distributions along with the vehicles speed timeseries resembled the behavior of drivers on an urban city.

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https://github.com/hector6298/titulacion_vehice_speed_estimation

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