Evaluation of the use of 3D LiDAR Point Cloud Data in Speed Enforcement Systems

Graduate

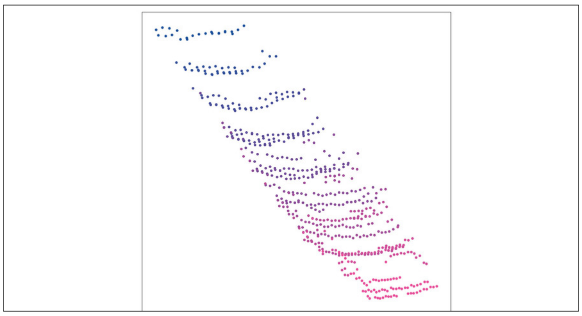
Amira Jäger

Definition of Task: This thesis evaluates the use of 3D LiDAR point clouds for speed enforcement. Currently LiDAR data in only two dimensions is most often used for speed enforcement.
The main reason for this thesis is, that accuracy does not translate to a competitive advantage, since they are either certified or denied. Instead, an advantage can be gain with quality of life improvements, such as surveiling additional lanes, or with additional data, for example classification of cars.

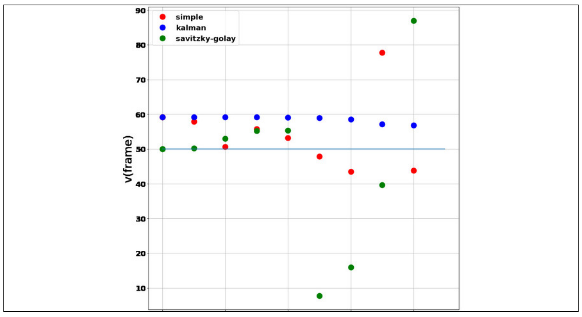
Approach: Neural network approaches were not feasible due to the sparsity of the available data. Instead, a classical signal processing pipeline is developed for estimating the speed of a series of 3D point clouds. For the photographic proof of exceeding the speed, a decision has to be taken by the processing chain in real time. Therefore, the focus is the development of lean algorithms that can be executed with low computation effort. After a background removal, each point cloud is collapsed to a single point. Those points are used to estimate speeds for each frame, either by dividing the distance by the time or by using different filters, such as a Kalman-filter. The series of speeds are filtered again to remove outliers and then aggregated to generate a final prediction.

Conclusion: While this thesis was not able to reach a point where it could be directly certified and used due to the limited accuracy reached, it shows promising results. A better LiDAR sensor is necessary, both the frame rate and the density of the point cloud should be increased greatly.
In addition, this work also shows some examples for neural network approaches which can be applied if more data was available and correctly labelled.

Example point cloud (background is filtered out). The data is relatively sparse and the car is represented as L-shapes.
Own presentment



Framespeeds, in a postprocessing step, outliers are removed and then combined into a final prediction.
Own presentment



Results of slow speeds (less than 40 km/h). The median error is lower than 2 km/h for almost all options.
Own presentment

postprocessing	aggregation	mean err[km/h]	median err[km/h]	valid pred
none	mean	3.85	1.80	48
none	median	3.05	1.51	48
none	savgol	4.65	1.61	37
none	savgol_adaptive	4.49	1.81	46
outlier	mean	3.68	1.80	48
outlier	median	3.10	1.51	48
outlier	savgol	3.85	1.41	34
outlier	savgol_adaptive	3.74	1.88	45
backtracking	mean	3.22	1.61	48
backtracking	median	3.25	1.54	48
backtracking	savgol	3.19	**0.95**	37
backtracking	savgol_adaptive	**2.84**	**0.90**	46
none	Kalman	6.60	2.84	47

Advisor
Prof. Dr. Christoph Würsch

Co-Examiner
Prof. Klaus Frick, Berufsmaturitätsschule Liechtenstein, 9490 Vaduz, Liechtenstein

Subject Area
Data Science

Project Partner
KISTLER AG, Winterthur, Zürich