# Traffic monitoring with Distributed Acoustic Sensing (DAS)

Marco Fontana, Supervised by Ángel F. García-Fernández, Simon Maskell

EPSRC Centre for Doctoral Training in Distributed Algorithms, University of Liverpool, Liverpool, UK

## Background & Aims

Distributed acoustic sensing (DAS) turns an optical fibre deployed for telecommunication purposes into an array of sensing units. The high sensitivity, low-cost and low-maintenance requirements make DAS an attractive solution for traffic monitoring compared to other sensors.

**Challenges**:

- The optical fibre output is highly affected by cabling, soil condition, and proximity of noise sources, which lead to time-varying and position-dependent signal-to-noise ratio (SNR).
- During peak hours, a high number of vehicles is present on the highway, leading to resolution and occlusion problems.

**Aims**:
To develop a system able to track each single vehicle on the highway, providing real-time estimations of speed and position, as well as the number of vehicles running on the highway.

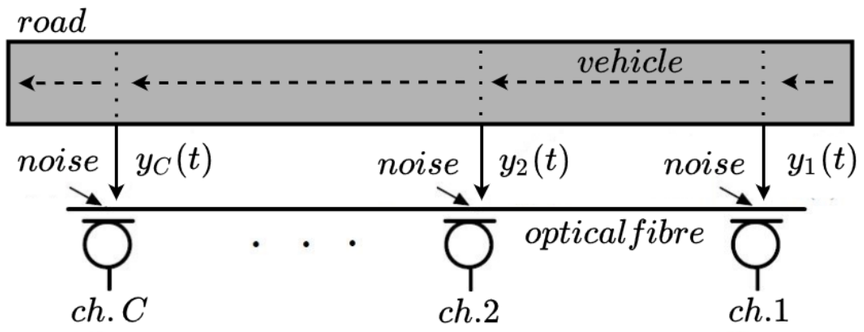


FIG 1: Schematic of DAS system configuration for traffic monitoring.

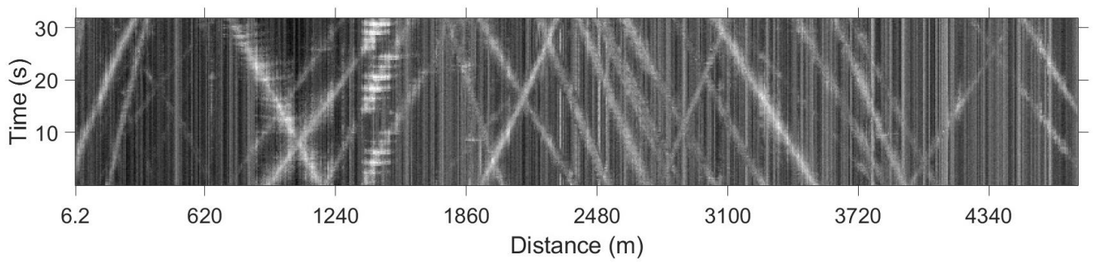


FIG 2: Example of DAS data represented in a spatio-temporal map, called waterfall.

## Detector

We are working on a new method that uses the concept of **notch periodogram** [1] to iteratively remove the contribution of the trajectories in the DAS data.

**Detection**: A maximum likelihood (ML) criterion is used to estimate the trajectory parameters according to an alphabet of possible speeds and arrival times.

**Trajectory features**: The trajectory signal is estimated via blob extraction [2], and it is used to detect false detections.

**Notch**: The detected trajectories are notched in each sensing unit signal, defining the orthogonal space in which to look for a new detection.

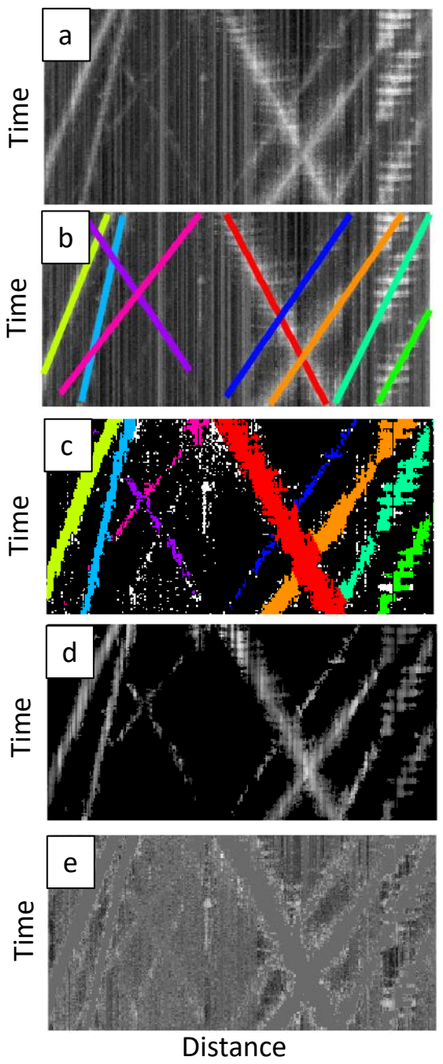


FIG 3: a) input data, b) estimated trajectories, c) data points associated with each trajectory, d) detected trajectories signals, e) residual.

## Tracker

We are developing a new tracker that takes in input the partial trajectories from the detector, also called **tracklets.**

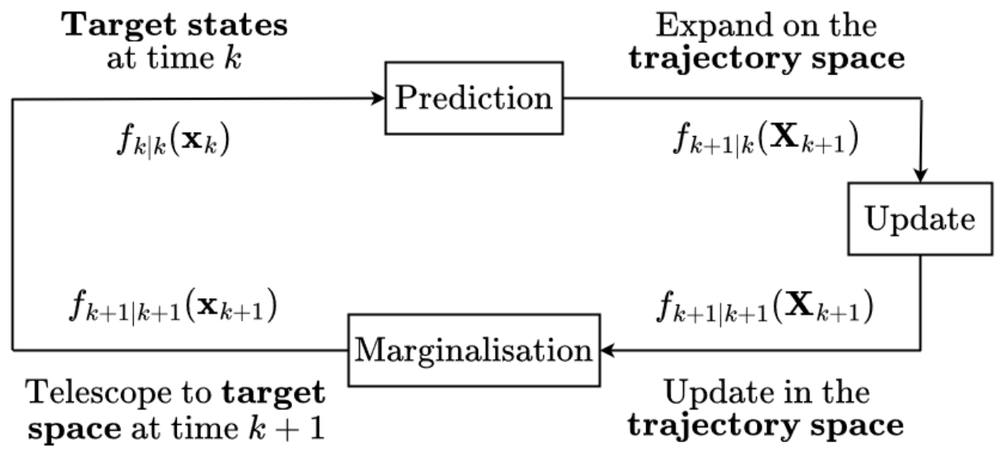


FIG 3: Schematic of the tracker of tracklets.

At each scan, the tracker can receive **full tracklets**, representing detections at the beginning and at the end of the time window, and **partial tracklets**, containing one single detection at time k or k+1.

This approach allow us to perform **sensor data fusion** of tracklets detected on different frequency bands in a efficient and scalable way.

## Future Work

- **Efficient multi-parameter estimation:** Analysis of methods to speed-up the current algorithm in high-traffic scenarios.
- **Occlusion detection:** Study of possible solutions to model trajectories running on the background of the waterfall, whose power is often occluded by other trajectories.
- **Clutter modelling:** Definition of a suitable clutter model to represent the variety of false tracklet measurements that can be received by the tracker.

## Conclusion

The notched power detector showed outstanding performance compared to the standard Hough transform detector [3], especially in high traffic scenarios. The tracker of tracklets is going to provide an estimation of the full trajectory of each vehicle on the highway.

## References

[1] J. K. Hwang and Y.-C. Chen, “Superresolution frequency estimation by alternating notch periodogram,” IEEE Transactions on Signal Processing, vol. 41, no. 2, pp. 727–741, 1993.
[2] M. B. Dillencourt and H. Samet, “A general approach to connected-component labeling for arbitrary image representations,” Journal of the ACM, 1992, 39, 253-280.
[3] M. Fontana, Á. F. García-Fernández and S. Maskell, "A vehicle detector based on notched power for distributed acoustic sensing," *2022 25th International Conference on Information Fusion (FUSION)*, 2022.

Engineering and Physical Sciences Research Council

UNIVERSITY OF LIVERPOOL

SINTELA