# Appendix to VAST 2018 submission <br> Analysis of Flight Variability: a Systematic Approach <br> by 

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Here we demonstrate the generality of the approach presented in the paper by applying it to example data and analysis tasks beyond the aviation domain.

## Data and analysis task



Data: 667 tracks of cars that travelled along motorway A4 on the north of Milan made during 1 week from April 1 to 7, 2007; 332 eastbound and 335 westbound tracks

Task: By comparing all tracks with the fastest eastbound and westbound trajectories (i.e., with the highest average speeds), determine where and when the cars could not move sufficiently fast and how their speeds differed from those in the two fastest trajectories.

Computed derived attribute for each point of each trajectory: mean speed in 2-minutes time interval starting from the time of the point.

## Trajectories in a space-time cube



2 fastest trajectories are represented by thick lines.

Green: eastbound trajectories
Purple: westbound trajectories

## Point-wise matching to the respective fastest trajectories



The points of each trajectory have been matched to the nearest points of the fastest trajectory going in the same direction. That is, the eastbound trajectories were matched to the fastest eastbound trajectory and the westbound trajectories to the fastest westbound trajectory.

The links between the corresponding points are represented in a space-time cube by dark yellow lines. For better readability, only trajectories from one day (April 7) are shown, when both fastest trajectories were made.
Red: the two fastest trajectories; green: eastbound trajectories; purple: westbound trajectories.
In the following slide, the links of the east- and westbound trajectories to the respective fastest trajectories are shown separately.

## Point matching for the eastbound and westbound trajectories



07/04/2007 00:00:00

$\ulcorner$ show the map on top of the cube 07/04/2007 00:00:00



07/04/2007 00:00:00
 07/04/2007 23:03:15 $\square$ Show the map on top of the cube 07/04/2007 00:00:00

## 

Based on the point-wise matching, the differences of the mean speeds by 2-minute time intervals between the points of each trajectory and their "buddies" from the respective fastest trajectory have been computed.

## Average speed differences along the road



The raster layer on the geographic map represents the average speed differences with respect to the fastest trajectories. The red end of the colour scale corresponds to the highest negative differences, i.e., the slowest speeds. The upper map shows the differences for the eastbound trajectories and the lower for the westbound trajectories.

This and other attempts to represent the differences on a geographic map do not reveal clear patterns. Therefore, we shall transform the trajectories to new coordinate systems (artificial spaces).

## Distance from the west end vs. speed difference



The trajectories have been transformed to a new coordinate system: distance from the west end (X-axis) vs. speed difference from the corresponding point in the fastest trajectory ( Y -axis).

The upper map shows the trajectories represented by lines in the new space. The lower map contains the density surface of the set of trajectories.

## Eastbound and westbound trajectories



This interactive map shows us where along the westeast direction many cars moving to the east and to the west had to slow down and how much slower they moved compared to the fastest trajectories.

## Time vs. speed difference



X-axis: time
$Y$-axis: speed difference
Upper map: trajectories represented by lines

## MI II

 * direction s$\square \bar{V} E(332)$
VW (335)
2 classes in total; 2 shown
Hide all Show all
Order classes by:
C sizes
C labels

- keep the table order
remove empty classes
restore full list
- Broadcast classification

Manipulate

Lower map: density surface

This map shows us when and how large deviations from the normal speeds (i.e., the speeds in the fastest trajectories) took place over the week.

## Eastbound and westbound trajectories



## Time vs. distance from the west end


$X$-axis: time
Y-axis: distance from the west end

Upper map: trajectories
represented by lines
Lower map: a coloured raster shows how the average differences to the speeds in the fastest trajectories are distributed over time and along the westeast direction.

This map shows us when, where, and how large deviations from the normal speeds took place over the week.

## Eastbound and westbound trajectories



## Time of the day vs. distance from the west end



Polar coordinates; angle: time of the day; radius: distance from the west end
Left: the trajectories are represented by lines.
Right: a coloured raster shows how the average differences to the speeds in the fastest trajectories are distributed over times of the day and along the west-east direction.

## Eastbound and westbound trajectories



Major deviations occurred in the morning times near the east end (i.e., at the entrance to the city area).

# Interactive "spatial" filtering: Eastbound trajectories with very large negative speed differences in the western part of the motorway 

Coordinates: distance from the west end vs. speed difference; raster: density; red rectangle: spatial filtering window


Coordinates: time vs. distance from the west end; raster: average speed difference


Coordinates: time vs. speed difference; raster: density


Coordinates: time of the day vs. distance from the west end; raster: average speed difference


## Interactive "spatial" filtering: <br> Westbound trajectories with large negative speed differences in the middle of the motorway

Coordinates: distance from the west end vs. speed difference; raster: density; red rectangle: spatial filtering window


Coordinates: time vs. distance from the west end; raster: average speed difference


Coordinates: time vs. speed difference; raster: density


Coordinates: time of the day vs. distance from the west end;
raster: average speed difference


