# Building a Visual Summary of Multiple Trajectories

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In our current research, we develop approaches to visualisation of large amounts of movement data, such as results of tracking animals, people, or vehicles. Traditional visualisation techniques, particularly, animated map and space-time cube, can effectively visualise a small number of geometrically simple trajectories made during a relatively short time period. However, with increasing number of moving entities, length of the time period, and/or geometric complexity of the trajectories, these displays soon become illegible. A possible approach to solve this problem is to visualise the data in a summarised form. A prerequisite for this is grouping of data items by similarity and spatial proximity. For this purpose, aggregation and clustering techniques may be used (Andrienko & Andrienko 2008, Rinsivillo et al 2008). An open problem is how to visualise a resulting group (cluster) of similar trajectories so as to give a clear idea about the commonalities between the trajectories and at the same time about the degree of internal variance in the cluster.

Furthermore, there is a need of simultaneous visualisation of multiple clusters of trajectories. The main problem is that trajectories are not disjoint in space; they intersect and overlap. As a consequence, summarized representations of groups of trajectories will also intersect and overlap if put in the same display. Hence, it would be appropriate to use a “small multiples” view, i.e. multiple juxtaposed maps or other displays each representing a single cluster. Since each of these displays has to be quite small, the clusters need to be represented in a highly schematic way such that only the principal features of each cluster are visible (but these features must be very easy to grasp). Such a representation may be called *graphical model* (Cheylan et al. 1997, van Elzakker 2004 pp.65-71). Our task is to find a way for automated generation of graphical models of groups of similar or related trajectories. Ideally, the degree of schematisation and the level of detail of a graphical model should be adjustable to the available display size and to the user’s needs.

A graphical model needs to convey important spatial and temporal relationships between trajectories. Currently, we are focussing only on the spatial relationships, such as common origin (i.e. the starting points of the trajectories being close in space), common destination (i.e. the ending points of the trajectories being close in space), full or partial spatial coincidence, convergence, divergence, parallelism, etc. A class of graphical models representing spatial relationships may be called spatial graphical models.

Our approach to building spatial graphical models of clusters of trajectories is based on the idea of summarising trajectories into aggregate moves between appropriately defined areas (Andrienko & Andrienko 2008). An aggregate move between two areas summarises a set of fragments of trajectories starting in the first area and ending in the second area. An aggregate move is represented on a map by an arrow with the thickness proportional to the number of trajectory fragments summarised in the move.

The main problem here is the generation of appropriate areas for building aggregate moves between them. Earlier, we have created areas by building circles around characteristic points of trajectories. However, this does not provide sufficient abstraction and schematisation. Our current approach is to use coarse partitioning of the territory by a special latticework built individually for each cluster depending on the properties of the cluster, in particular, the similarity function applied for the clustering.

Figure 1 demonstrates a possible representation of a cluster of trajectories with common ends (the cluster includes about 1500 trajectories of cars moving in the city of Milan). In order to build the graphical model represented in Figure 1 right, we generated a web-like lattice around the area of concentration of the end points of the trajectories.

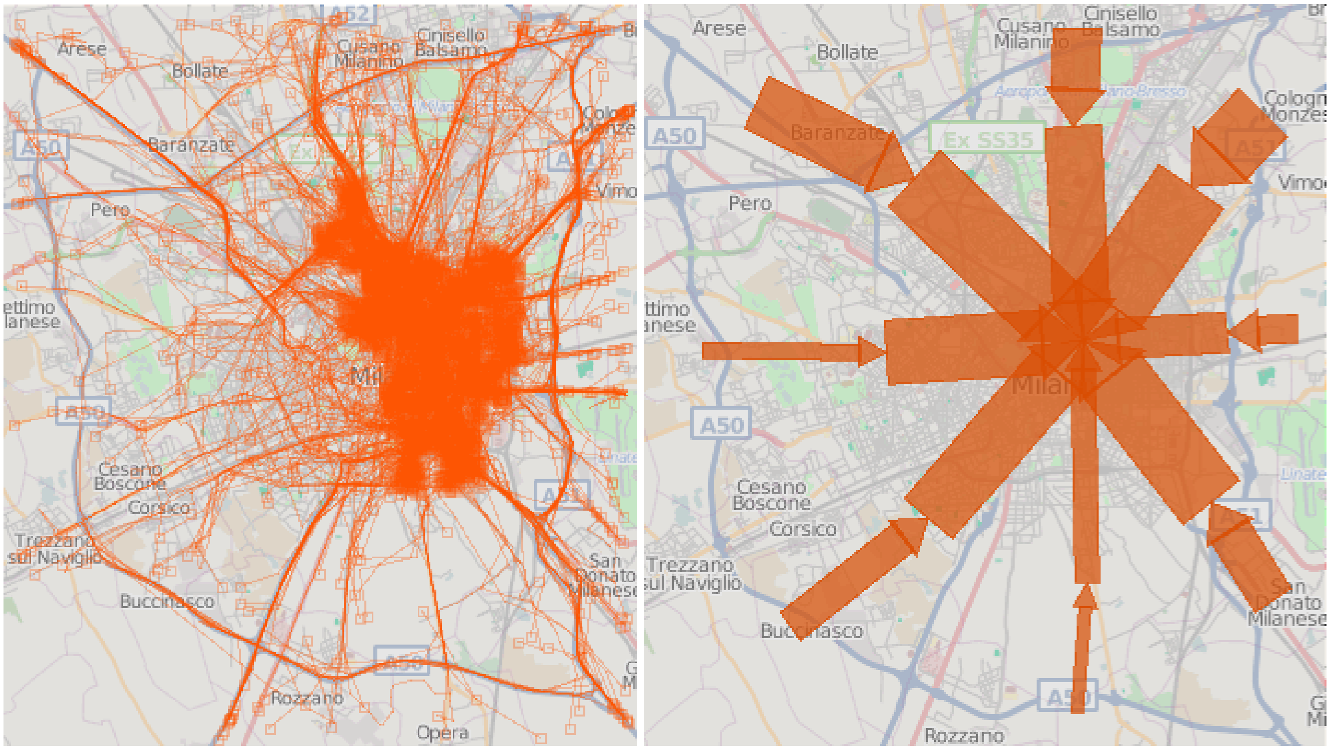


Figure 1. A spatial graphical model representing a cluster of trajectories with common ends.

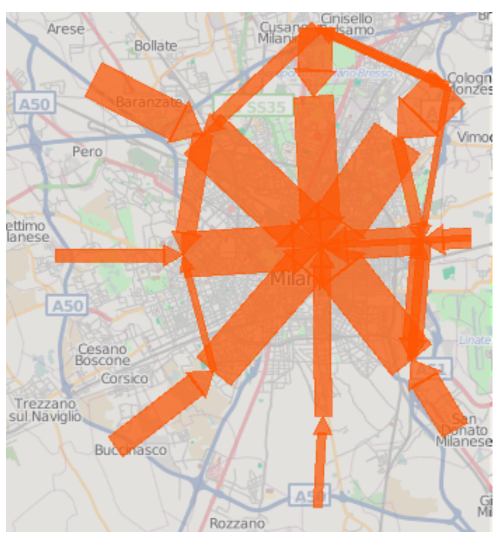


Figure 2. Another graphical model for the cluster of trajectories shown in Figure 1.

The degree of schematisation can be controlled by changing the granularity of the space partitioning (using smaller or larger areas) and by filtering the resulting aggregate moves (e.g. omitting minor moves, which stand for a small number of trajectory fragments). Thus, the spatial graphical model in

Figure 2 results from the same space partitioning as the one in Figure 1 (right) but includes additional aggregate moves.

Figure 3 shows a cluster of trajectories with similar routes (top left) and three possible spatial graphical models differing in the levels of detail. The underlying lattice was constructed according to the idea of magnetic field lines between two poles. As the poles, we used the gravity centres of the starting and ending points of the trajectories.

On the current stage of our research, we experiment with different principles of territory division for the summarisation of trajectories. Our goal is to develop a generic framework and a set of efficient algorithms for building spatial graphical models of groups of trajectories.

## REFERENCES

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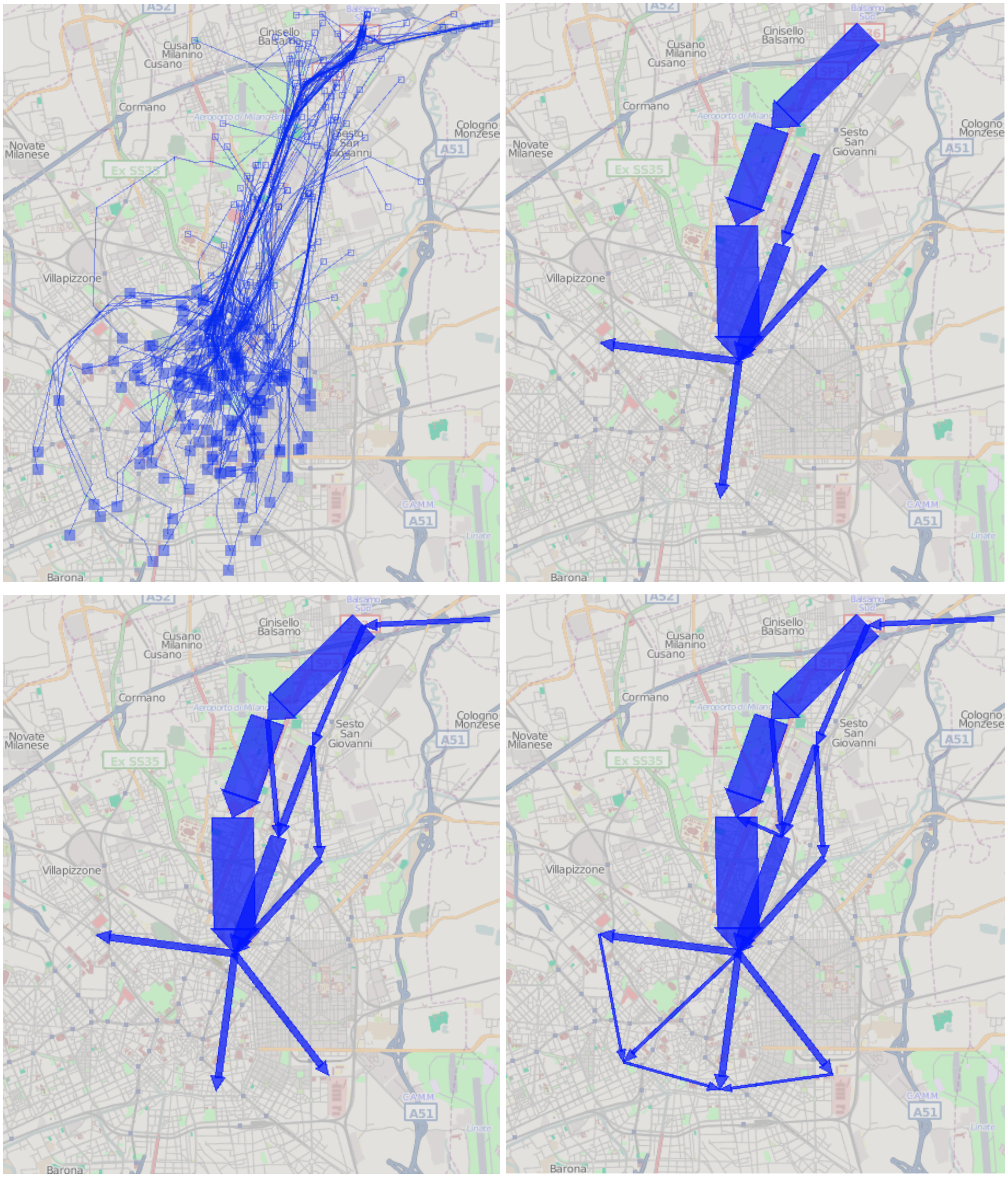


Figure 3. A cluster of trajectories with similar routes and possible spatial graphical models with different levels of detail.