Application of an Adaptive and Directed Kernel Density Estimation (AD-KDE) for the Visual Analysis of Traffic Data

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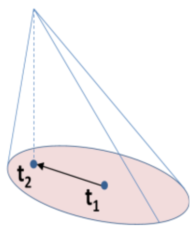
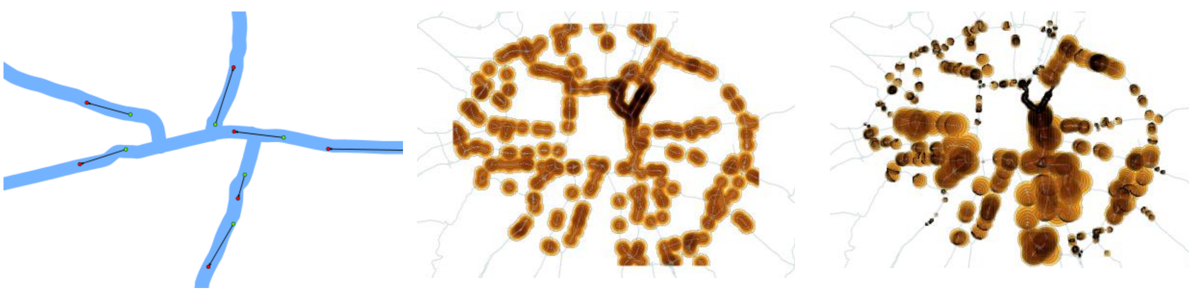
Abstract— Remote sensing and tracking technologies (such as tracking mobile phones and in vehicle navigation systems) have enabled us to store the position of individual cars over time. A number of previous studies have investigated methods to display the density of cars on a road network. These density maps show density of vehicles moving on the street as an isopleths map within a city or region at a single instance. Often these investigations use the well known kernel density estimations (KDE) to display static densities (and traffic hot-spots) representing one point in time. This "classic" method may reveal the traffic hotspots, but it does not recognize the movement trends within dynamic point data representing the individual cars. Therefore we investigate how to display the dynamic component of point densities and the density changes. We take two points in time (set1 and set2) representing the individual vehicles positions and apply an adaptive directed kernel density estimation (AD-KDE), which recognizes the underlying dynamics of the individual points.



In a case study we apply an AD-KDE to a point dataset representing individual cars approaching or leaving the city of Munich. The dataset is clustered with an nearest neighbour classificaion based on the 10 closest neighbours. Then we apply to each cluster an adaptive directed kernel, which is based on features of the individual point, (like movement direction and speed) and of features influencing the movement of the point (number of points in the approximation based on the nearest neighbour cluster and in the next steps the shape of the road network) illustrated in Figure1.

Figure 1. Illustration of applying a directed kernel based on two points in time

Applying the AD-KDE to our test dataset results in a density map, which incorporates the influencing factors. The visual output differs from the density maps that is calculated with a classic KDE approach which is shown in Figure 2 abc.



a.) b.) c.)

Figure 2. : a.) simulated point dataset representing individual cars in two points in time (green for starting point, red for “end” point) on the Munich main roads, zoomed in a small part of the road network; b.) a density map based on a kernel density estimation applied to the simulated point set1 representing the cars strting points; c.) a density map based on an adaptive and directed kernel based on the cars starting and “end”points

First informal discussions indicate that this method supports the visual analysis and prediction of hot spots based on the dynamic points and therefore may be suited for near-real-time visualizations. A careful visual comparison between the AD-KDE and a “classic” kernel density map indicates the general motion direction of the vehicle clusters and the velocity in a reasonable way. A more formal investigation will reveal if the AD-KDE method and the resulting visualizations are understood easily by defined user groups dealing with traffic density analysis.

Index Terms— Geostatistics, Kernel Density Estimation (KDE), Directed Kernel Density Estimation (DKDE), Geovisualization, VisualAnalytics.

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