Density Map Based Trajectory Visualization for Low Speed Objects

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Abstract. Trajectories of moving vehicles contain data concerning traffic environments, vehicles, and vehicle users in real-time. In order to support effective trajectory analysis, some visualization methods for vehicle trajectory were proposed. Due to the technological limitation and high cost of the satellite tracking system, most of the trajectory visualization methods were focused on the large scale. In this study, we propose a small scale trajectory visualization method. The proposed method is based on the density map and highlights the areas where the trajectories with different kinematic properties are intersecting each other. Our visualization method 1) divides trajectories into several groups according to the kinematic properties, 2) generates the density map for each groups, 3) generates the intersection map which visualizes the area that the groups are intersecting, and 4) combines the density map with intersection map. In order to evaluate the method, the bicycle GPS trajectories collected from segregated bicycle track were visualized. The experimental results showed that our visualization method was able to provide some visual insights which is hard to be noted from the large scale visualization methods.

Keywords: Trajectory visualization, Density map, GPS, Bicycle

1 Introduction

The trajectories of the vehicles have valuable data on real time traffic which is not available from a map, and they have been studied to analyze traffic environments, vehicle status, and user behaviors [4-6].

In order to assist the vehicle trajectory analysis, researchers on information visualization suggested the trajectory visualization methods which emphasize the meaningful features of the trajectories in various ways [1, 2]. Most of the previously proposed trajectory visualization methods were focused on the large scale visualization of the travel path because most of the trajectories were collected by using fast and wide range vehicles (i.e. motor vehicle, airplane, and vessel). However, as the technology of the satellite tracking system and handheld device improved and...
came into wide use, it became easy and popular to collect the travel log from daily lives.

The travel trajectories are different for the transportation modes [3]. Suppose a pedestrian, bicycle, and motor vehicle traveled on a same section of a street. Their trajectory outlines could be similar. However because of their different behaviors, the kinematic properties (i.e. speed, acceleration, and heading direction) and the detail of the moving trajectories will be dissimilar to others.

In this paper, we propose a small scale trajectory visualization method which is proper to visualize objects with a low speed and complex travel path. In order to support the understanding of the trajectories, the proposed method divides the trajectories according to the kinematic properties and generates a density map for each trajectory group. The main contribution of this study is to visualize the differences and similarities among the density maps generated based on the trajectory groups and provide information concerning the interaction among the trajectories. The intersection between density maps was examined and utilized as a different type of density map. The proposed method was applied to the visualization of the bicycle trajectories collected from a segregated bicycle track.

Detail of the proposed method and implementation will be shown in section 2. The experimental visualization results will be shown in section 3. In section 4, we draw conclusions and suggest future work.

2 Method

The proposed method divides the trajectories into several groups according to the kinematic properties of the trajectory points. The kinematic properties can be speed, acceleration, or heading direction. Based on the trajectory groups, the density maps were generated with the kernel density estimation. The Gaussian density kernel was applied to the density map. After the density map procedure, the intersection map which represents the intersection area among the density maps was generated.

\[
i_{(x,y)} = \begin{cases} 
  d_{(1,x,y)} + d_{(2,x,y)} & \text{if } d_{(1,x,y)} > 0 \text{ and } d_{(2,x,y)} > 0 \\
  0 & \text{otherwise}
\end{cases}
\]

Equation (1) shows the building process of the intersection map. \(i_{(x,y)}\) indicates the value of intersection map at the position of \(x\) and \(y\), and \(d_{(i,x,y)}\) is that of the density map with group number \(i\). In order to highlight the intersection map values and provide more effective visual information, the intersection map was combined with the density map. The value of the intersection map was subtracted from \(r_{\text{subtract}}\) or added to \(r_{\text{add}}\) that of the density map.

\[
\begin{align*}
  r_{\text{add}} &= d_{(1,x,y)} + i_{(x,y)} \\
  r_{\text{subtract}} &= d_{(1,x,y)} - i_{(x,y)}
\end{align*}
\]
3 Experiments

The proposed method was applied to the trajectories collected from the segregated bicycle track in Seoul. Collected trajectories were divided into two groups according to their heading directions. Next figure shows the example of divided groups with two colors. The blue colored lines show the trajectories moving to the right (east) and red colored lines indicate the trajectory group moving to the left (west).

![Example of trajectory groups](image1)

**Fig. 1.** Example of trajectory groups

![Example of density maps, intersection map, and their combinations](image2)

**Fig. 2.** Example of density maps, intersection map, and their combinations

Fig.2 shows the example of the experimental results. The density of the trajectory group is shown with graduating color ranged from light blue to red. In the figure, (A) and (B) shows two density maps of the trajectory groups. (C) shows the intersection map and (D) is a density map of all groups. The result map of the add combination is shown in (E) and the subtract combination is given in (F).
From the intersection map, (C), we can find the area with high density which can be interpreted as the area with many bicycles moving in the opposite directions. The high density area which colored purple to red was about 5% of the whole inspected track. In order to find the relation between the bicycle crash risk and the high density area, further investigations are needed.

4 Conclusion

In this paper, we proposed the small scale visualization method for low speed object based on the density map. The proposed method focused on the fact that the kinematic properties of the low speed objects are more complex than those of the fast speed objects. Based on this, we divided the trajectories into several groups based on the kinematic properties of the trajectory points. Divided trajectory groups were utilized to generate their own density maps. Based on the density maps, the intersection map which shows the intersecting area among the density maps was generated and combined with the density maps to provide more effective visual information. The proposed method was tested with the trajectories collected from the segregated bicycle track, and showed its usefulness to find the high density areas.

For the future work, we will attempt the relation between the bicycle crash risk and the high density areas. Several risk analysis models will be utilized with the crash spot information.

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References