PROJECTION OF TRAJECTORY FOR SUPPORTING UNCERTAINTY FUTURE TIME OF MOVING OBJECT

*Ho-Gyeong Won, *Young Jin Jung, *Yang Koo Lee, *Mi Park, **Hak-cheol Kim,* Keun Ho Ryu

*Database/Bioinformatics Laboratory, Chungbuk National University, Korea
*{hogyong, yjjeong, leeyangkoo, pmi386, khryu}@dblab.chungbuk.ac.kr,

**Electronics and Telecommunications Research Institute(ETRI),Korea
**david90@etri.re.kr*

ABSTRACT:

Uncertainty of objects in Moving Object Database is a coherent property. It has been discussed in a lot of researches on modelling and query processing. The previous studies assume that uncertain future time is determined through utilizing recent speed and direction of vehicles. This method is simple and useful for estimating the time of the near future location. However, it is not appropriate when we estimate the time of the far future location.

Therefore, in this paper, we propose a concept of planned route. It is used to estimate uncertain future time, which has to be located at a given point. If the route of an object is planned beforehand its locations are uncertainly distributed near that route. By a simple projection operation, the probability that a location lies in the planned route is increased. Moreover, we identify the future time of an object based on the speed for passing the route, which is offered via a website.

KEY WORDS: Moving Object, Uncertainty, Planned route, Projection, Traffic information

1. INTRODUCTION

Capturing moving objects and processing information have led to many scientific works in moving object databases. Many researches have been tried to made progress in accurately modelling moving objects and processing queries[1,2,3], index for effective search and update[1,4,5]. Specially, location update that is reflected uncertainty has been focusing[3,6,7].

Traditionally, trajectory of a moving object is modelled as a continuous three-dimensional line. Moving objects have the continuous movement and also have the uncertain property, which is caused by procrastination of the networks and automatic error[8,9,10]. In the previous studies, an uncertain future time was made with through utilizing the recent speed and direction[11,12]. This method is very useful for estimating the time of the near future location. However, it is not appropriate when we estimate the time of the far future location, because a moving object is not fixed speed and direction till destination. In this study, we include traffic information while identify the information about the objects' planned route. Traffic information is general data. Therefore we revise traffic information by the average past speed of the moving objects.

The rest of this article is structured as follows. Section 2 reviews some previous work. A description of trajectory model and construction is introduced in section 3. Section 4 presents how to project trajectories. Estimation of future time is described in section 5. Section 6 concludes the paper and gives some future work.

2. RELATION WORK

It is necessary to describe the movement of an object in order to capture its spatial and temporal characteristics. Moving objects is traditionally described as a sequence of the finite set of points in three-dimensional space, called trajectory. Trajectory is sampled in terms of regular time. And because of automatic error and procrastination of the network it is always uncertain. Thus the correct expression of trajectory cannot be obtained[8,9,10].

The uncertainty of moving objects has been studied actively in the fields of space and time. Although moving object is located in a suburb of a trajectory, we cannot say exactly at some specific time point and in an identified location. That is the temporal uncertainty. The expected location of the moving object within a temporal interval of moving object is the spatial uncertainty. Recently a research on integrating the spatial uncertainty and temporal uncertainty has been done[8,9,10].

Assumption on the uncertain future time with the use of the recent speed and direction information is introduced[11,12]. This method is very useful for estimating the time of the near future location. However, it is not appropriate when we estimate the time of the far future location. There are other researches on the geographical objects or traffic information[13]. In our research, estimation of future time is done with the use of the traffic information and with regard to the average past speed.

3. TRAJECTORY MODEL AND CONSTRUCTION

In this chapter, we introduce trajectory model and construction. Trajectory model represent the object locations in the form of a sequence of points with the time intervals.

A Trajectory is expressed by the following function $f: T \rightarrow (x, y)$.

$$(x_1, y_1, t_1), (x_2, y_2, t_2), \cdots, (x_n, y_n, t_n), (t_1 \prec t_2 \prec \cdots \prec t_n)$$

A segment is a basic unit that is used to constitute a trajectory. Actually, moving object does not move in a straight line and does not have uniform velocity. Thus, its location on a segment is determined by an interpolation at each time instance. A 3D Trajectory Tr is projected on a plane, called Route of TR.

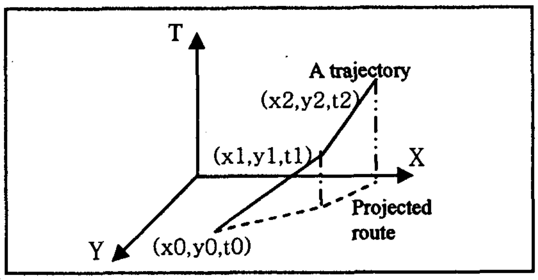

Figure 1. Trajectory model

We define a planed route of a moving object as a sequence of points excluding time dimension in the following:

$$(x_1, y_1, t/f, V_{traffic}), \cdots, (x_n, y_n, t/f, V_{traffic})$$

Where t/f standing for True/False indicates the passage possibility of moving object; V is the velocity of object on the corresponding segment.

4. PROJECTION OF TRAJECTORY

The real locations of a moving object do not accord with a planed route. However, it is quite probable to be located in that route. Therefore, we project the locations of uncertainty moving object on a planed route for the good of probability. Projection information is used to identify the future time.

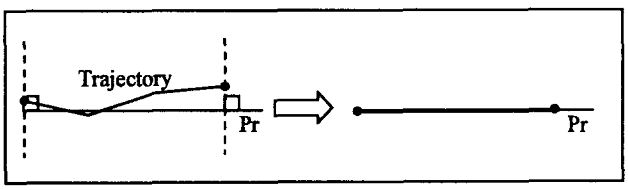

Figure 2. projection of trajectory

Figure 2 illustrate that a moving object having a real trajectory TR will have a planed route Pr after projecting. The whole trajectory is not projected, because we can get the useful information by projecting only its two end points.

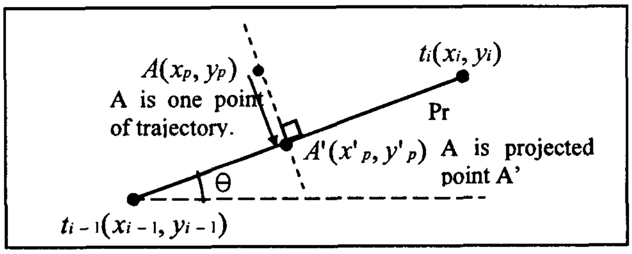

Figure 3. projection of a point

Figure 3 illustrate that point $A(x_p, y_p)$ has the projected route Pr. The coordinates (x_p', y_p') of the projected point A' is calculated by the following equation.

$$x'_p = \frac{x_p + \tan^2\theta \times x_i + \tan\theta \times y_p - \tan\theta \times y_i}{\tan^2\theta + 1}$$

$$y'_p = \tan\theta(x'_p - x_i) + y_i \qquad \left(\tan\theta = \frac{x_i - x_{i-1}}{y_i - y_{i-1}} \right)$$

Planned route Pr is the expressed linear function. So tanθ is gradient of planned route Pr. This means coordinate (x', y') that it crosses point A and meets the trajectory vertically.

5. ESTIMATION OF FUTURE TIME

5.1 Revision of the planned route

It uses the speed information per a section. The offered speed means an average speed of many unspecified objects in a section. Therefore, an error exists between the offered speed and the passage speed of a given object. To reduce this error, it is necessary to revise the speed in a given route. The revised speed $V_{revision}$ can be calculated using this formula.

$$V_{revision} = \alpha \times V_{traffic}, \quad \alpha = \frac{V_{p\_traffic}}{V_{trajectory}}$$

Where $V_{p\_traffic}$ means average speed of many unspecified objects in the past; $V_{trajectory}$ is an average speed of given object.

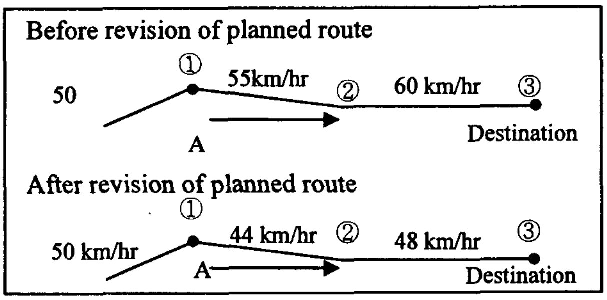

Figure 4. Example: Revision of planned route

For example, if an average speed of object A is 40km/hr in figure 4, then $\alpha = \frac{V_{p\_traffic}}{V_{trajectory}} = \frac{40}{50}$, so planned route can correct.

5.2 Estimation of future time in an object

This section proposes Estimation of future time in an object. The future time is like below.

$$T_{future} = \sum \frac{D_{distance}}{V_{revision}}$$

For example, if the distance of sections 1,2 is 1km and sections 2,3 is 2km in figure 4, the passage time A is expected 3.86 minutes in order to pass the route all. Formula is $T = (1/44 + 2/48) \times 60$, the reason why we multiply 60 is to converse time granularity into minute.

5.3 Estimation of future time in numerous objects

This section suggests an algorithm for answering queries like "what is the time when a given moving object will be inside a given region".

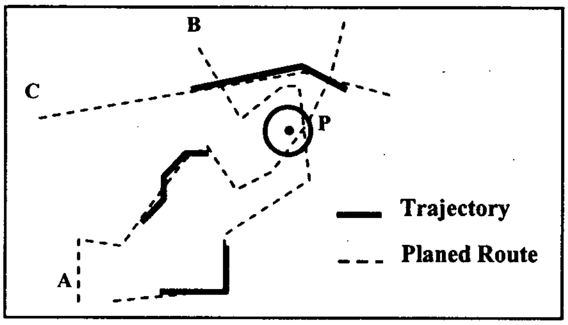

Figure 5. Query point and trajectory of moving objects

This suggestion considers not only one object but also numerous objects and choose the object that pass the given earliest in Figure 5. For example, Assume that objects A, B shown in figure 5 have passed the filtering step, then their future times can be calculated using previously presented formula, and decide which one is included in the result.

```
Algorithm Filtering step
  Input: trajectory of objects
  Output: candidateTr)
Begin
  Loop
    If (distanceTr <= radius)
      candidateTr =+ result
    End If
  End loop
  Return candidateTr
End
```

Figure 6 Algorithm of Filtering Step

Our algorithm consists of a filtering step and a refining step. In filtering step, we choose the objects, which intersect a given spatial region at some time in figure 6.

```
Algorithm: Refining step
  Input: candidateTr
  Output: objectID, Time
Begin
  Loop(all of candidateTr)
    projection(candidateTr)
    assumeTime(all of point projectionTr)
    If (resultTime > assumeTime)
       resultID =+ assumeID
       resultTime =+ assumeTime
    End If
  End loop
  Return resultID + resultTime
End
```

Figure 7 Algorithm of Assume of Future Time

We project their trajectories on a given route. The output of the algorithm is the estimated future time after the refining step in Figure 7.

The Estimation of future time is useful objects with planned route which is bus service home-delivery service, etc.

6. CONCLUSION

We have introduced the way to determine the uncertain future time of moving objects in bus service, home-delivery service etc and also having the defined the trajectory of a moving object using the concept of planned route. If the route is planned, the location of object is uncertainly distributed near a route. By a simple projection operation, the probability that an uncertain location lies in a route is increased. We merely want to get the necessary information by projecting both end points of a trajectory on a plane. Moreover, we identify the future time of an object based on the route speed which is offered via a website. Additionally, we supplement an average speed of given moving objects because offered speed via a website is the general information. Finally, we proposed an algorithm for answering queries with a handling of numerous objects. Currently, we are going to take further consideration to reflect concise information such as road information, weather, transfer, and the conditions of the objects, etc. In addition we will composite the study on the spatial uncertainty and time uncertainty.

Acknowledgements:

This work was supported by the RRC program of MOCIE and ITEP.

References

[1] A.P.Sistla, O.Wolfson, S. Chamberlain, and S.Dao. "Modeling and querying moving objects." In 13th Intl Conf. on Data Engineering (ICDE), 1997.

[2] M.Vazirgiannis and O, Wolfson. "A spatiotemporal model and language for moving objects on road networks". In SSTD, 2001.

[3] A.P.Sistla, O.Wolfson, S. Chamberlain, and Y.Yesha. "Updating and querying databases that track mobile units." Distributed and Paralled Databases, 7, 1999.

[4] D.Kollios, D. Gunopulos. And V.J.Tsotras. "On indexing Mobile objects". In 18^{th} ACM PODS Conference,1999.

[5] A.P.Sistla, O.Jensen. "Indexing of moving objects for location-based services." In Intl. Conf. on Data Engineering, ICDE, 2002.

[6] D.Pfoser and C.jensen. "Capaturing the uncertainty of moving objects representation." In SSDB, 1999.

[7] G.Trajecvski, O.Wolfson, F.Zhang, and S. Chamberlain. "The geometry of uncertainty in moving objects databases." In EDBT, 2002.

[8] G.Trajcevski. "Probabilistic Range Queries in Moving Object Database with Uncertainty." In Association for Computing Machinery, 2003.

[9] G.Trajcevski, O.Wolfson, K.Hinrichs, S.Chamberlain. "Managing uncertainty in moving objects databases." In ACM Transactions on Database Systems (TODS), 29(3), pp. 463-507, 2004.

[10] G.Trajecevski, O.Wolfson, Fengli, and S.Chamberlain. "The Geometry of Uncertainty in Moving Objects Databases." In ACM Transactions on Database Systems (TODS), 29(3), pp. 463-507. 2004

[11] A.Yun-Ae, R.Keun-ho. "Management of Uncertain Position Information of Moving Objects." In The Research Institute for Computer and Information Communication, Vol. 9, No1. 2001.

[12] O.Jun Seok, L.Eung jae, R.Keun-ho. "Vehicle Location Management System in Mobile Environment." In KIPS, Vol. 9-D. No, 6. 2002.

[13] B.Taewook, A.Kyounghwan, H.Bonghee. "Indexing of Moving Objects and Query Processing for Uncertainty in Road Networks." In KISS, 2004.