

## A STUDY ON VEHICLE POINT CORRECTING ALGORITHM IN GPS/AVL SYSTEMS

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### ABSTRACT

AVL system is a successful application of the integration of GIS and GPS. When GPS data is displayed on a GIS map, logically the vehicle point should be displayed on the roads. But because of the effect of errors, there are always warps between the true vehicle point and the displayed point on the map. It is necessary to correct these warps. In this paper, we put forward two algorithms: Linear Abstraction Algorithm (LAA) and its improved one—Buffer Linear Abstraction Algorithm (BLAA). Experimental results show that both algorithms have perfect precision. And the shortcomings of the algorithms are also pointed out.

### 1. INTRODUCTION

Nowadays, the application of 3S (GIS, GPS and RS) is developing towards the direction of integration. In this kind of integration, GPS is used to provide spatial position information of objects real-timely and quickly; RS is used to provide semantic or non-semantic information of objects and their environment real-timely or quasi- real-timely, while GIS is used to do some integrating disposal, integrating management and dynamic access to multi-source temporal and spatial data. GPS/AVL system is a successful application of the integration of GIS and GPS.

In a GPS/AVL system, when a GPS mobile object (a vehicle, for example) is displayed on a map, logically the vehicle point should be displayed on the roads. But because the effect of low-precision of map, errors of map digitizer, errors of GPS system, errors of GPS receiver, there are always warps between the true vehicle point and the displayed point on the map. But the precise position of a mobile object is a key to the system, so it is badly necessary to correct these warps. The authors put forward a correcting algorithm— Linear Abstract Algorithm (LAA) and its improved one—Buffer Linear Abstract Algorithm (BLAA).

### 2. A STUDY ON THE ALGORITHM

In brief, LAA and BLAA are such algorithms that we should first make linear abstract of the road layer (Put these line segment objects into a single MapInfo hidden layer) of a map and then make correction based on the hidden layer. Before correction, we process the map according to the request of algorithm design, which includes creating a linear layer to simulate the road layer and creating a layer which contains objects representing crossroads and so on.

### 2.1 LINEAR ABSTRACTION OF ROADS

Linear abstraction of roads is the foundation of LAA and BLAA. In a MapInfo map, roads are represented as region objects, so when we create the linear road layer (We call it linear layer), it's naturally for us to apply central lines to simulate road objects. Thus we get the linear layer. It is not necessary to be very precise when you draw the lines, but they must be able to represent the roads. If a road is not very straight, we use several line segments to simulate it. The lines in the linear layer are used to calculate the position of corrected vehicle point.

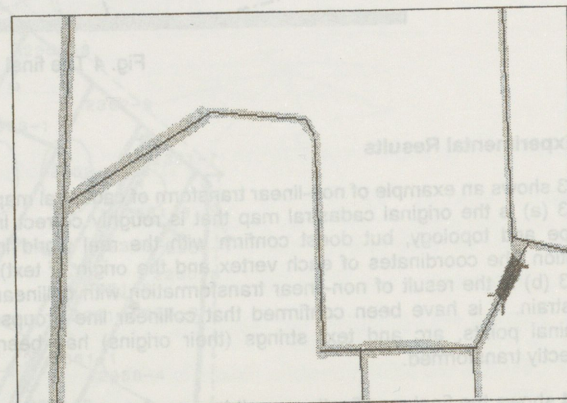


Fig. 1. Linear layer

### 2.2 GET THE CROSSROAD LAYER

Crossroads are special points for vehicles: vehicles may turn left or turn right, vehicles may stop before a red light and the names of roads may change and so on. So we must deal with these conditions specially. Just like the linear abstract of road layer, we should also create a crossroad layer, that is, create a layer that contains objects situating at the positions of the crossroads on the road layer. This layer will be used to judge the spatial relationship between vehicle points and crossroads. Fig. 2 shows the crossroad layer.



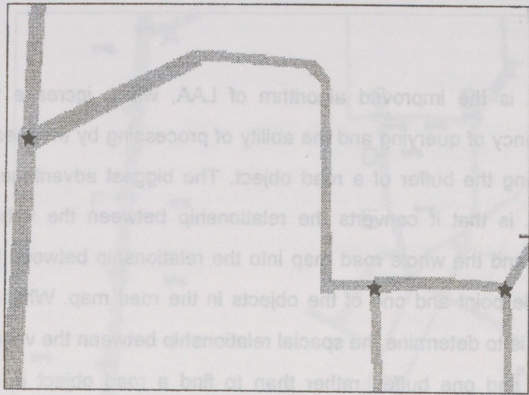


Fig. 2. Crossroad layer.

### 2.3 THE LAA ALGORITHM

After these preparing work, we come to the algorithm. The basic of LAA is to find a road nearest to the vehicle point and put the corrected point on the line segment that represents the road. We can get the position of the corrected point by calculating the vertical point of a point to a line. The details of the algorithm is as following.

#### Step 1

Draw a circle, taking the vehicle point as the central point and selecting a suitable value (According to precision of GPS receiver GN-77, 100m is OK.) as radius. The circle should not be displayed on the interface. Judge whether the circle intersects with objects in the crossroad layer, if there are more than one object, then reduce the radius until there is only one crossroad in the circle. Put the corrected point on the position of the crossroad and get a next point and return to step 1. If there isn't any object in the circle, go to step 2.

#### Step 2

Judge the relationship between the circle (Whose radius may change) and the objects in the road layer. If there are more than one object in the road layer that intersect with the circle, then reduce the radius, else increase the radius, until there is only one object that satisfies the condition. Record the name of the road.

#### Step 3

If the name recorded is the same as the one of last time, then go to step 4; otherwise we know that the vehicle is nearer to another road than the former road. But we don't know whether the vehicle turns (Look at Fig. 3 and Fig. 4), so we just ignore this point, get next point and return to step 1.

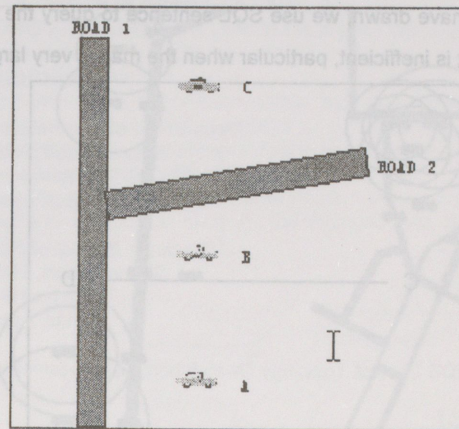


Fig. 3 Point C should be corrected to ROAD 1.

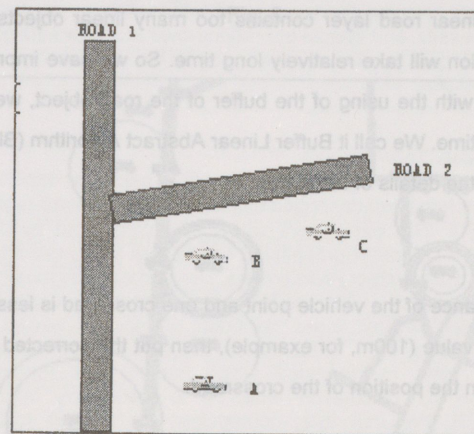


Fig. 4 Point C should be corrected to ROAD 2.

#### Step 4

Use the method in step 2, get an object in the linear layer which is nearest to the vehicle point.

#### Step 5

In a MapInfo map, we are able to get the end points of a line segment object. Look at Fig. 5, if we know the coordinates of point A, B and C, it is easy to know the coordinates of point D. We can calculate the vertical point of the vehicle point to the line segment in the linear layer which is nearest to the vehicle point. It is the corrected point we want.

#### Step 6

Put a point on the corrected vertical point, get a next point, return to step 1.

### 2.4 THE BLAA ALGORITHM

In LAA Algorithm, when we determine the relationship between the road layer, the linear road layer, the crossroad layer and the



circle we have drawn, we use SQL sentence to query the whole layer, so it is inefficient, particular when the map is very large

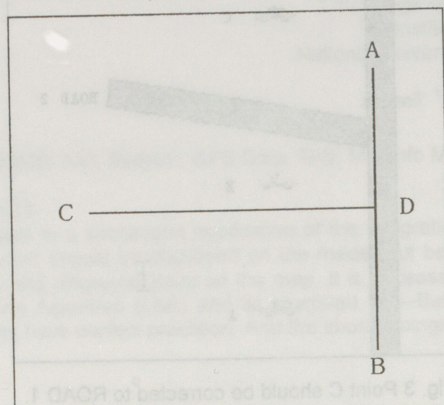


Fig. 5

and the linear road layer contains too many linear objects, the query action will take relatively long time. So we have improved the LAA, with the using of the buffer of the road object, we can save our time. We call it Buffer Linear Abstract Algorithm (BLAA). Here are the details of the algorithm.

#### Step 1

If the distance of the vehicle point and one crossroad is less than a certain value (100m, for example), then put the corrected point directly on the position of the crossroad.

#### Step 2

If there is no crossroad point which will satisfy the condition, then find the road object which is nearest to the point. The road should locate between two crossroad points. Then create the buffer of the road object, the radius of the buffer depends on the precision of the GPS receiver, for GN-77 receiver, 100m is OK.

#### Step 3

Determine the relationship between the vehicle point and the buffer. If the vehicle is in the range of the buffer, then put the objects of the linear road layer which intersect the buffer on space position into a temporary table, then do the correcting algorithm in this temporary table. Generally, its much smaller than the whole linear road layer, this is the key point of efficiency.

#### Step 4

If the vehicle point intersects no buffer, we just determine that the vehicle is no longer on the original road. Go to step 1.

#### Step 5

Put the corrected point on the map. Get the next point and go to

step 1.

BLAA is the improved algorithm of LAA, which increase the efficiency of querying and the ability of processing by the means of using the buffer of a road object. The biggest advantage of BLAA is that it converts the relationship between the vehicle point and the whole road map into the relationship between the vehicle point and one of the objects in the road map. What we need is to determine the spacial relationship between the vehicle point and one buffer, rather than to find a road object in the whole road map. Note that it takes time to create a buffer in MapInfo. So if there are not too many objects in a map, BLAA may have no advantage against LAA; but if the map is very large (i.e. contains many objects), you'd better use BLAA.

### 3. SIMULATION RESULTS

MapInfo is the most prevalent desktop GIS, and MapBasic is an ideal programming language based on the MapInfo platform. The authors realize LAA algorithm by integrating MapInfo into VB 5.0.

We use the map of North District of Changsha in the experiment, and the GPS receiver is a GN-77 receiver, Fig. 6 shows the result of the experiment, the points on the roads are corrected points.

Look at point A, there is a crossroad near it, the distance between the crossroad and the vehicle point is less than 100m (87.3m in deed). So according to step 1 of LAA, we should put the corrected point on the crossroad. Similarly, we put corrected points of point B and point C respectively on crossroad nearest to them. But at point D, road DE is the nearest to point D. However, we can't decide whether the vehicle is to go straight or is to turn left, so according to step 3 of LAA, we ignore this point. Point E is a common point. The names of the road nearest to point D and point E are of the same, so we put the corrected point of E on the line segment nearest to it. The coordinates are calculated in step 5 of LAA. Other points like point F are the same as point E.



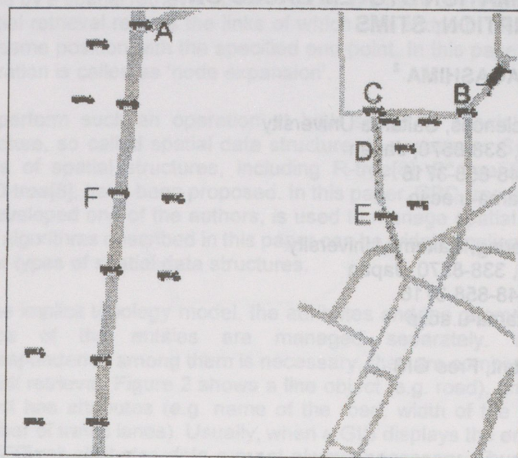


Fig. 6

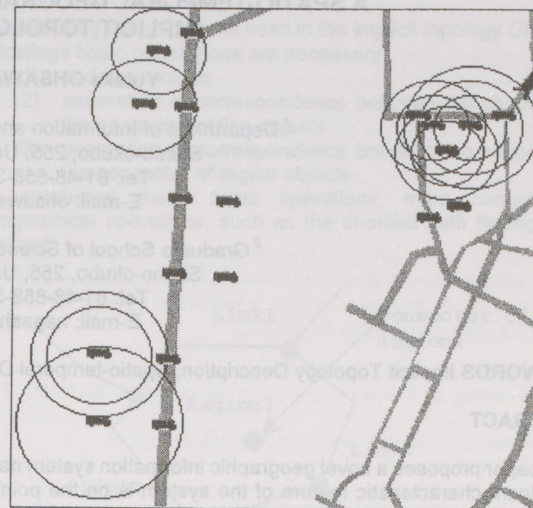


Fig. 8

If we display the circles we draw in the steps of LAA, we have

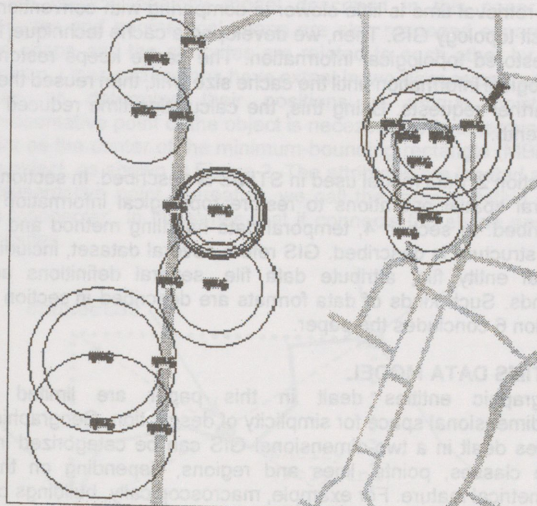


Fig. 7

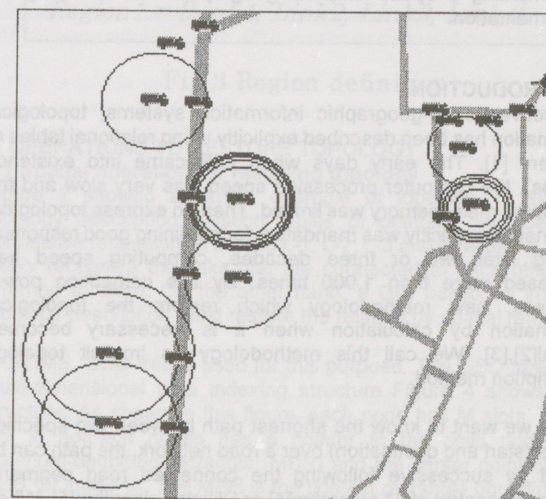


Fig. 9

Fig.8 and Fig.9 show the process of BLAA, the circles in Fig.8 are drawn when we are searching for the object in the road layer which is nearest to the vehicle point. Whereas the circles in Fig.9 are drawn when we get the temporary table and do the correcting in the temporary table.

#### 4. CONCLUSIONS

LAA can correct the warps accurately and can simulate the real vehicle point to the largest extent. The algorithm can also deal with some special circumstances such as crossroads.

But, from the scheme of LAA, we know that to correct one point we must query at least 3 tables many times, if the tables are very large, it will take much time to query a table, it is obviously not suitable for a real time condition.

#### 5. REFERENCES

- MapBasic Professional Reference, 3<sup>rd</sup> Edition October, 1996
- MapBasic User's Guide, 3<sup>rd</sup> Edition October, 1996
- MapInfo Professional(4.5) Reference
- MapInfo Professional(4.5) User's Guide

And also, there are many special points that are not discussed in this paper, LAA can't deal with those conditions. But we will confront them in real work. To solve these problems, further research is expected.