REAL-TIME SPATIAL ANALYSIS FOR GPS/GIS-BASED AVL SYSTEM

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ABSTRACT

In AVL, GIS analyze the information from the vehicles to provide commercial or other value for user. As spatial analysis functions in GIS make a new valuable information using the vehicle's position and geographic object's location, they perform an important roles to improve the management efficiency of vehicles. Most GIS however are used static data for the spatial analysis, so the research area on AVL used dynamic vehicle location has generated unsuitable result. In this study, we use GPS real time tracking data to perform spatial analysis between moving vehicle and static geographic object. The method proposed in this paper considers the driving direction of vehicle and creates the result which is located in forward of vehicle. In this paper, two spatial analysis functions, near and connectivity, are developed.

INTRODUCTION

Nowadays, GIS (Geographic Information System), as multi-discipline information system, is closely linked with GPS (Global Positioning System) application in conjunction with GIS-T (GIS for Transportation), Logistics, CNS (Car Navigation System), or AVL(Automated Vehicle Locatior). Especially, GIS plays two important roles in transportation planning and analysis : firstly, the use of GIS in processing geographically related data; and secondly, the use of GIS for performing spatial analysis, not only for obtaining new information, but also to augment decision support by allowing the development of 'what-if' scenarios[Kim, 1997]. However, most GIS, which are generally used as an analysis tool for AVL, analyze static data such as digital map that is revised at long time intervals. As there is a moving vehicle in AVL, traditional spatial analysis can generate an unsuitable results. In this study, the real-time spatial analysis functions : near and connectivity which include the moving vehicle as a reference/target of spatial analysis are implemented.

AVL COMPONENTS

The AVL system offers traveling information, traffic information, and others to driver of vehicle in order to shorten the time taken in traveling and reduce the cost covered. It consists of three basic attributes, each representing a different technology[Noda 1995, Regan 1995, Nelson 1995]. AVL systems provide a means to locate the vehicles. The highly precise global positioning satellite system is the preferred method for vehicle location. Second, they provide a means to communicate the location to the service or security provider. This requires mobile data telemetry. Third, they analyze the information from the vehicles to provide it with commercial or other value. This is accomplished with GIS software which plots the vehicle locations (spatial information) on suitable maps. GIS software links location information with data based information (non-spatial attribute information). GIS software also provides real time links to existing CAD (Computer Aided Dispatch) or MIS (Management Information System) software. These AVL system provides three strong benefits to a transit agency[Egeberg, 1995]. The first benefit is the availability of necessary data to optimize routes. This optimization allows for reduction in runs, fewer vehicles deployed and improved on time performance. The second benefit is improved safety. AVL can significantly shorten the time required for emergency vehicles to respond to an incident. The third benefit is improved on-time performance. The availability of accurate and timely vehicle location provides dispatchers with the required information to better manage the on-time performance of the fleet. This data also provides passengers with real time information about vehicle arrival times.

SPATIAL ANALYSIS IN GIS

At the early stages of development, GISs were envisioned to provide functions such as acquiring, storing, data conversion, manipulation, and presenting geographic data for decision making. According to definition of ESRI (Environment System Research Institute), in addition to others mentioned above, a complete GIS must provide spatial analysis functions. Indeed, it is the spatial analysis capability that differentiates GIS from desktop mapping software[Chou, 1997]. We developed several spatial operators for complex and advanced geo-processing : near, adjacency, connectivity, containment, contained, and buffering.

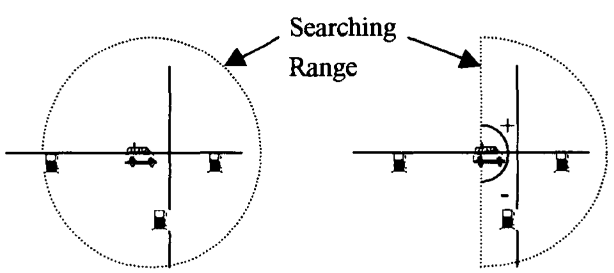
REAL-TIME SPATIAL ANALYSIS IN AVL

Dynamic data in GIS is defined as geographical objects which change in time either by position or attributes. Changes are no longer expressed in long time intervals in tens of years, but in minutes and second. Dynamic data can have either a fixed position with dynamic attributes or have a dynamic position, or both. For example, a monitoring station can have a fixed position, but collected data changes in time. It is desirable to combine static and dynamic data.

Most GIS are used static data, as reference and target, for the spatial analysis. AVL however have to process real-time spatial analysis using dynamic data such as moving vehicle. In this case, the traditional spatial analysis of GIS generate unsuitable results. We developed a real-time spatial analysis which has not only static geographic objects as target but also a moving vehicle as reference. The real-time spatial analysis algorithms proposed in this paper were applied to near and connectivity method.

Near Analysis

The most fundamental function of spatial analysis in GIS is the Near function which identifies the near objects that are within a specified distance range from a reference object[6]. A reference object and target object can be static geographic object in traditional GIS. In AVL, however, a reference object and a target object can be moving vehicle or static geographic object. Near could apply several cased : finding out a service station or a gas station, and so on. In this study, we consider the direction of moving vehicle and extract the result objects within searching range. There is no passed object which exists the backside of vehicle in result object. Figure 1 represented the difference between static analysis and dynamic analysis. The gas station A, B, and C were result of static near analysis (Figure1-(a)), on the other hand B and C were result of dynamic near analysis (Figure1-(b)) proposed in this study. The value of θ should be changed according to vehicle's speed. If a vehicle runs at high speed, the value of θ is reduces. If a vehicle runs at slow speed, the value of θ is increased. The range of θ is between 45 degree and 90 degree.

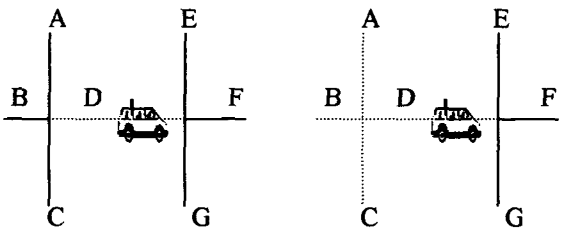


(a) static near analysis (b) dynamic near analysis

Figure 1. Comparison between static and dynamic near analysis

Connectivity Analysis

Connectivity indicates whether two roads are connected[6]. Connectivity is especially useful for transportation and routing analysis. This in a transportation network is important for determining the shortest path from a given address to another. In traditional GIS, connectivity of roads can be determined from the attributes of the two end intersections (called from-node and to-node) of road, that is, two roads are directly connected if both are linked to the same intersection. In this real-time spatial analysis, as we consider the direction of moving vehicle, connectivity can be determined at one intersection, which is located in the forward of moving vehicle, of the two end intersections. The passed intersection in road excepted. Figure 2 represented the difference between static analysis and dynamic analysis. In Figure 2-(a), a vehicle run on road D and the static connectivity analysis made the result set containing the road A, B, C, E, F, and G. On the other hand, the dynamic connectivity made the result set containing the road E, F, and G (Figure 2-(b)). Because the result of dynamic analysis was reduced a half of static analysis, the volume of transmission data through wireless communication network was reduced and the transmission speed was faster.



(a) static connectivity analysis (b) dynamic connectivity analysis

Figure 2. Comparison between static and dynamic connectivity analysis

EXPERIMENTS AND RESULTS

In order to implement the dynamic analysis algorithm presented in this paper, it was developed that a system consisted of three elements: host, PCS (Personal Communication System, wireless communication network), and vehicle. Test driving was taken placed in the area of Taejon, fourth biggest city in Korea with over 1.3 million populations.

We show the result of this algorithm in Figure 3, Figure 4, Figure 5, and Figure 6. Figure 3 and Figure 5 represented the dynamic analysis. Figure 4 and Figure 6 represented the static analysis.

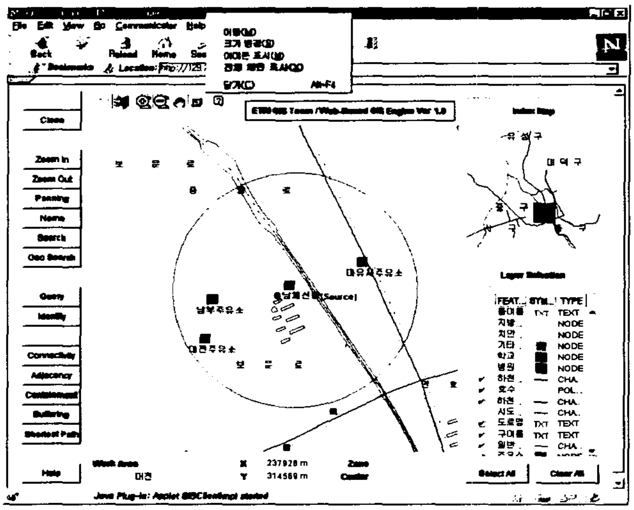


Figure 3. An example of static near analysis in GIS

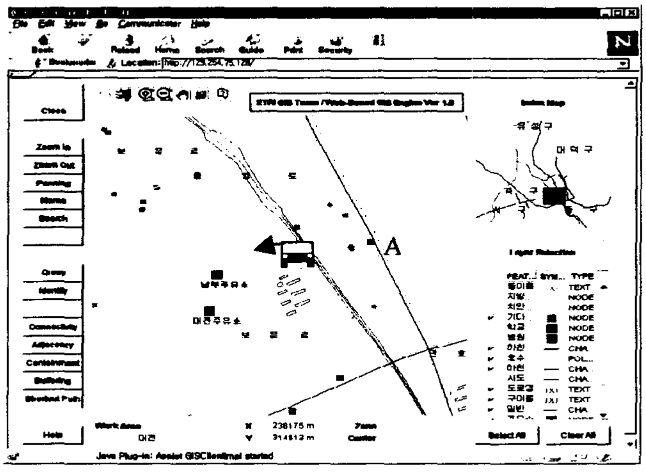


Figure 4. An example of dynamic near analysis in AVL

In Figure 3, the blue box, Chungnam Regional Communication Office, is source object and the blue circle represents the searching range which radius is 500m. The three read boxes, gas station, represent the result of static near analysis. In Figure 4, the black arrow represents the driving direction of vehicle and the two read boxes represent the result of dynamic near analysis.

The backward gas station, A, of the vehicle is discarded by this dynamic analysis.

In Figure 5, the blue line is source object, road 78. The five read lines, road 77, road 84, road 74, road 97, and road 73 are the result set of static connectivity in GIS. In Figure 6, the black arrow represents the driving direction of vehicle running on road 78 and the two read lines represent the result roads of dynamic connectivity analysis. It is discarded by this dynamic analysis that three roads, road 74, road 97, and road 73 are located in the backward of vehicle.

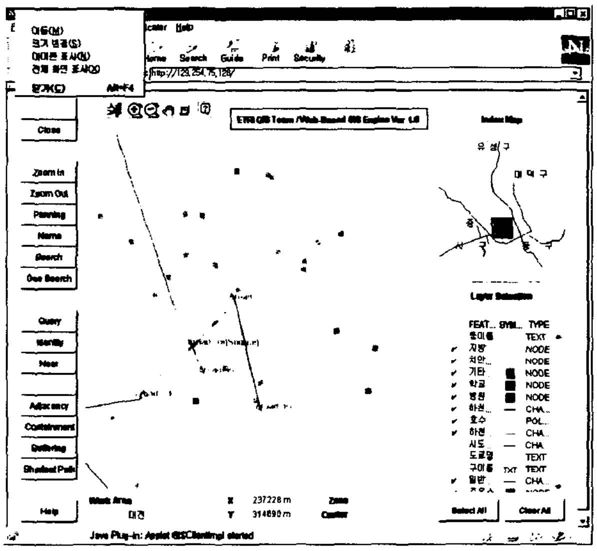


Figure 5. An example of static connectivity in GIS

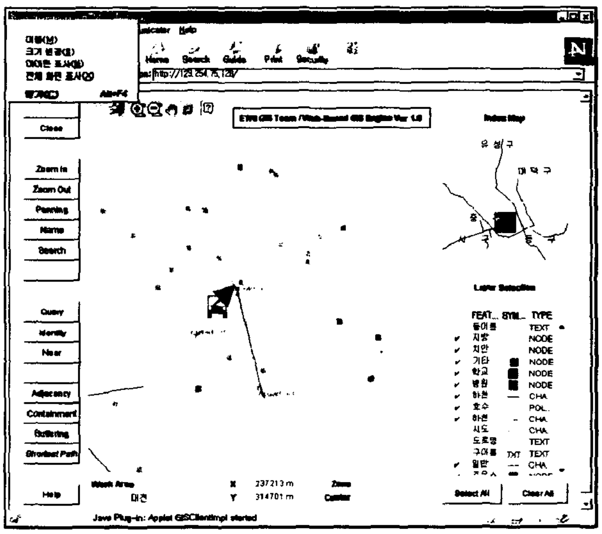


Figure 6. An example of dynamic connectivity analysis in AVL

CONCLUSIONS

GIS/GPS-based real-time spatial analysis functions, near and connectivity, are implemented in this study. In real-time application, especially AVL system, high transmission speed is one of the most important factors. We focus on reducing the volume of transmitted data. Two spatial analysis functions developed in this paper consider the dynamic position and the direction of vehicle. We gain two advantages. First, we reduce the number of result geographic objects of spatial analysis as it excludes all geographic objects which are located in backward of vehicle. Second, the transmission speed is fasted because the volume of transmitted information is reduced.

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