Continuous Perspective Query Processing for 3-D Objects on Road Networks

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Abstract. In order to provide a streaming service of 3-D spatial objects to the mobile clients on a street, we propose a new query type, called continuous perspective query. The perspective query differs from conventional spatial queries in that the levels of details (LOD) of query results depend on the distance between the query point and spatial objects. The objects in the vicinity are to be provided with a higher LOD than those far from the query point. We are dealing with continuous queries, and the LODs of the results are also changing according to the distance from the mobile query point. The LOD of the result object changes from a low LOD to a high LOD as the mobile query point approaches to the object. In this paper, we also propose a processing method for continuous perspective query to reduce the processing cost at a server and communication cost between the server and the mobile clients.

Keywords: continuous perspective query, road network, LOD, 3-D objects.

1 Introduction

Most location-based services provide mobile users with the information of spatial objects such as buildings and roads in 2-D or 2.5-D. However we may achieve a higher quality of services when the 3-D information is offered such as 3-D geometry, and colors and texture on the facets of the objects. This information enables more realistic visualization of objects than simple 2-D data.

One of the main problems in providing 3-D information to mobile clients comes from the large size of data. It is almost impossible to store a large volume of 3-D data in a mobile device such as a PDA and a mobile phone with a relatively small size of memory. Furthermore, the transmission of 3-D data is limited due to the narrow bandwidth of wireless communication.

The basic idea of this paper is based on the observation that we do not need a detail information on an object which is far from the query point but only its simplified sketch in rendering aspects. However, more information is progressively required as the query point becomes closer to the object to describe it in detail. In this paper, we propose a new type of query, called continuous
perspective query for this purpose. This query is a kind of continuous query, where the levels of details (LOD) of query results depend on the distance between the query point and spatial objects. The objects closely located to the query point are to be provided with a higher LOD than those far from the query point.

Since we are dealing with continuous queries, the LODs of the results are also changing according to the distance from the mobile query point. The LOD of the results should be upgraded as the mobile query point approaches to the object. Also an efficient protocol of upgrades reduces the communication cost and processing cost at the server. For this reason, a method is proposed to process the continuous perspective query and upgrade LOD in this paper.

The remainder of paper is organized as follows. In section 2, we review related work in perspective query and continuous query. We describe the basic concept and define continuous perspective query in the next section. In section 4, we propose a processing method for the query for the mobile clients on streets. An analysis of performance is presented in section 5 and we conclude the paper in section 6.

2 Related Work and Motivation

A perspective query is to request data which have different levels of detail according to the importance of data. In GIS and LBS, this type of query is used to optimize the processing of geo-visualization. We may simplify a certain level of geometries of objects that are relatively far from the viewpoint to reduce the size of data. For this type of query, several researches have been done since last few years. For example, a processing method was proposed for perspective query by selecting proper LOD (Level of Detail) based on the range from the viewpoint in [4]. By this method, the entire space is divided into three ranges according to the distance from the viewpoint and a proper LOD is assigned to each range from high LOD to low LOD.

LOD-R-trees was proposed to index spatial objects with LOD in [2], which is a new data structure combined with R-trees and LODs. It stores the graphic data of spatial objects at each node and returns properly simplified LOD according to the distance. Similarly, V-Reactive tree was proposed in [3], which is another variant of R-trees for multiple LODs. It can be used for implementing the generalization of multi-LODs technique.

However the mobility of viewpoint has not been considered by these work. In most applications of perspective query such as LBS and navigation services, the spatial query condition continuously changes for a given period of time. During this time period, the queries are to be repeatedly evaluated for providing the correct information as the spatial query condition changes. This query is called continuous query [1]. Recently, a lot of attention has been paid to continuous range query and continuous $k$-nearest neighbor query as shown in table [1].

Among these work, we refer the work related to the continuous range query processing because a perspective query can be regarded as a range query. A