Continuous Moving Pattern Mining Approach in LBS Platform

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Abstract: Moving pattern is as a kind of sequential pattern, which can be extracted from the large volume of location history data. This sort of knowledge is very useful in supporting intelligence to the LBS or GIS. In this paper, we proposed the continuous moving pattern mining approach in LBS platform and LBS Miner. The location updates of moving objects affect the set of the rules maintained. In our approach, we use the validity thresholds that indicate the next time to invoke the incremental pattern mining. The mining system will play a major role in supporting the various LBS solutions.
Keywords: Moving Patter, LBS

1. Introduction

LBS aims to accurately identify individuals' locations and, by applying this information to various marketing and services, provide more personalized and satisfying mobile service to its users. The service can particularly be applicable to the sectors with changeable locations over time, such as PDA, mobile telephone, automobile, airplane, etc. Such changeable entities, in terms of location and pattern over time, are defined as "moving objects"[1,2]. The temporal changes of moving objects tend to possess a unique, regular pattern. This pattern can be traced by using the temporal data mining technique[3]. The pattern of moving objects which is discovered by data mining can be quite useful to location-based information service in identifying users' moving paths [3].

Recently, as the increasing interests on location-based service in mobile environment, many studies on location data processing have been developed. But these methods have been focused on such as the location data management, indexing and trajectory management. Moving pattern is as a kind of sequential pattern, which can be extracted from the large volume of location history data. This sort of knowledge is very useful in supporting intelligence to the LBS or GIS. The previous method [3], however, have some limitations and drawbacks on mining of moving data that occurs too frequently in real world. In this paper, we proposed a continuous moving pattern mining approach by extending the previous moving pattern mining in LBS platform and LBS Miner. The location updates of moving objects affect the validness of the rule maintained. In new approach, we introduce the validity threshold that indicates the confidence level of the current rules. This means that the periodic mining can be performed very cost effectively. The proposed approach is now applied to the LBS Miner to extract moving patterns from moving object database in LBS platform.

2. Moving Pattern Mining

2.1 Problem Definition

Moving Objects change their locations continuously as seen figure 1. We define a sequence of moving object to be an ordered list of locations such as areas. Generally, a length of a sequence is very long since the moving is not bounded. So, a sequence of a moving object need to be considered as a set of disjoint unit sequences for better processing. Each unit sequence means one consecutive moving of a moving object semantically. We call this as moving sequence. Moving pattern is defined as the frequent regularity of location change over time. In order to discover the patterns, we need the database of location changes, geographic information and user's measurements for interesting patterns.

Given moving objects database (***MODD***), background geographic information(***GIS***), user given thresholds such as user-assigned minimum support (***min_sup***), user-assigned time constraint(***max_gap***), maximum moving sequence range(***max_span***),minimum distance(***min_dist***) and generalization level(***gen_threshold***), the moving pattern mining involves searching for all frequent generalized moving sequences that satisfy the user thresholds.

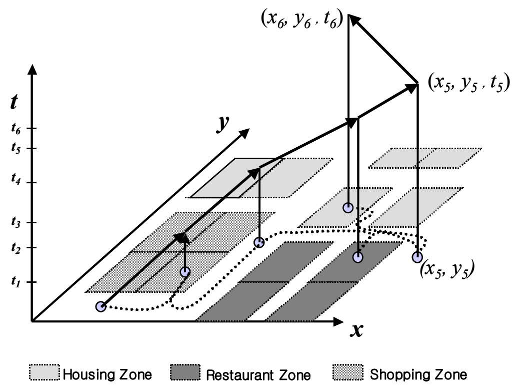

Figure 1. Location Changes in Space

2.2 Moving Pattern Mining

Moving pattern mining consists of three major stages like figure 2. Location generalization means the transformation of location into more abstract level of location. Relationships between spatial geometries are hierarchical. This is called as spatial concept hierarchy. Using this hierarchical feature, location is generalized into more meaningful spatial location. The user threshold, ***gen_threshold***, controls the level of abstraction. Moving sequence generation stage extracts the moving sequences form the generalized data. In this stage, the user given thresholds, ***min_dist*** and ***min_gap***, are used. These thresholds affect the distance and time gap between each movement in sequence. The last stage extracts the interesting regular patterns from the moving sequences. The user measurements of interestingness for discovered patterns is minimum support(***min_sup***) and maximum span(***max_span***).

The discovered moving patterned is stored into knowledge base. However, as the increasing of MODB, knowledge based need to be freshen.

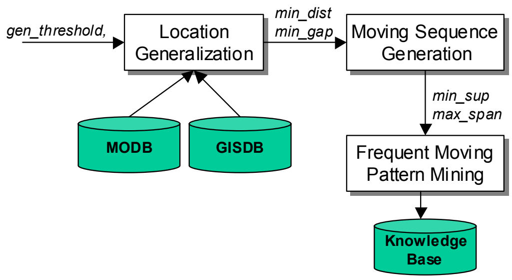

Figure 2. Process of Moving Pattern Mining

2.3 Continuous Moving Pattern Mining Approach

The MODB is append-only feature. Therefore, new location changes of an object are appended into MODB. Because there is no update of history data, existing patterns is valid until the user thresholds for patterns are given. The newly appended moving object data affects the new set of rules to be maintained in rule base.

Our continuous mining approach based on the incremental approach. Therefore, moving pattern mining module is invoked continuously and mines the new patterns by using two kinds of validity threshold such as cardinality threshold and interval threshold. The cardinality threshold indicates the maximum amount of newly appended data while interval threshold indicates the maximum interval from the last pattern mining. Using validity threshold, we get the differential data(***Δmodb***).

Moving pattern mining module described in section 2.2 needs to be slightly modified to support the continuous mining. As seen in figure 3, the extended version of miming module handles the differential data (***Δmodb***) together with candidate moving patterns(***candidate_mps***) discovered previously and generate the new valid moving patterns(***valid_mps***) and candidate patterns(***candidate_mps***). This is continuously performed until the user thresholds for patterns are not changed.

However, this approach involves two important issues need to be addressed. The selection of validity threshold and the access overhead to MODB affects the performance. To lessen these overheads, we use the main-memory structured GISDB and MODB.

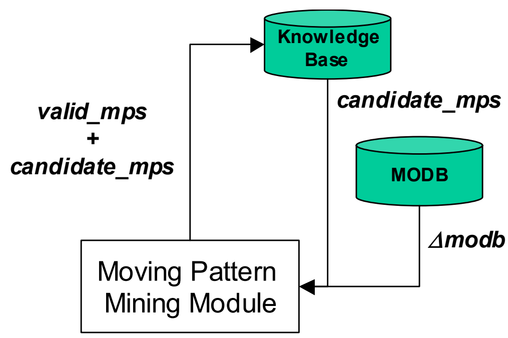

Figure 3. Our continuous pattern mining approach

3. Mining System for LBS

Our developing mining system consists of 5 major components such as moving object database component(MODB), GIS component, knowledge base component, knowledge service components and LBS miner. Our system closely interacts with LBS platform and provides knowledge via knowledge service components. Currently, moving pattern knowledge is available only.

3.1 LBS Platform

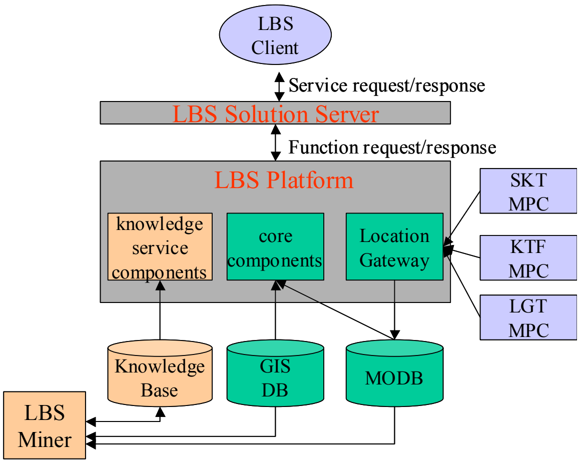

Figure 4. LBS platform with LBS Miner

Our developing LBS platform seen in figure 4 has the capabilities of such as location gateway service, core component services, and knowledge services. MODB manages the location data acquired by using location gateway service. Core components serve the requests of various functions such as location utilities function, routing and presentation functions for LBS solution. These functional requests are sent to core components by means of web service messages and controlled by platform manager.

3.2 LBS Miner

LBS Miner in figure 5 extracts useful knowledge to support the various knowledge-based LBS solutions. Currently, this miner supports the moving pattern mining only. However, other spatial or temporal knowledge discovery module will be integrated.

The GIS DB and MODB in the LBS platform are implemented as main-memory structured system. Therefore the proposed continuously mining approach can be easily applied without the performance overhead.

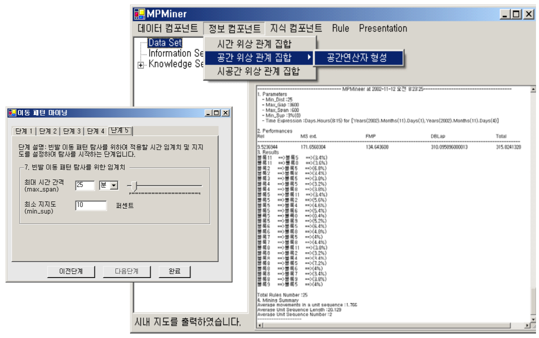

Figure 5. MP Miner for LBS

3.3 Knowledge Service Component

The discovered moving patterns are managed in knowledge base. These patterns can be utilized to the various LBS services. This pattern knowledge used to predict the future movements. Moreover, this can be used to analyze the characteristics of movement for each customer segments. The recommendation style services may use this knowledge. We are implementing the knowledge service components as EJB components in order to serve the LBS solutions.

4. Conclusion

To provide more intelligent services, spatial knowledge such as moving pattern is very essential in LBS services.

In this paper, we proposed a continuous moving pattern mining approach based on LBS platform and the LBS miner system. The system consists of the 5 components and generates useful moving patterns. The system will play a major role in serving the various LBS solutions.

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