MVUC: An Interactive System for Mining and Visualizing Urban Co-locations

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Abstract. Spatial co-location patterns and rules may reveal the spatial associations between spatial features whose instances are frequently located in a spatial neighborhood. This paper develops an interactive system for Mining and Visualizing Urban Co-locations (MVUC) from the Point Of Interest (POI) datasets of cities. According to user-specified thresholds, MVUC efficiently mines maximal patterns based on instance-trees. Then MVUC concisely demonstrates the table-instances of patterns on map based on the convex hull algorithm, intuitively illustrates areas in which the consequents' instances of rules possibly appear on map based on the intersection of areas, and visually figures patterns by graph. MVUC also allows users to compare co-locations in different regions. MVUC can help users with analyzing the functional regions of cities, selecting the locations for public services, and other urban computing.

Keywords: Spatial data mining · Co-location mining · Co-location visualization · Urban co-location

1 Introduction

Mining spatial co-location patterns and rules is one of the most important tasks of spatial data mining. A co-location pattern is a subset of spatial features whose instances are frequently located in a spatial neighborhood. A co-location rule reflects that the table-instance of the consequent pattern is frequently co-located with the table-instance of the antecedent pattern. So co-locations may reveal the spatial associations among spatial features, and have attracted interest from researchers. However, existing works, such as join-based approach, partial-join approach, join-less approach and order-clique-based approach [1], mainly focus on reducing the cost of mining co-locations. Distinct from the above, we aim to visualize co-locations, and help users to understand and utilize co-locations.

On the other hand, with the development of modern technologies such as GIS and GPS, an amount of spatial data, such as Point of Interest (POI) datasets and road networks in cities, have been collected and need to be analyzed by using spatial data mining technologies such as co-location mining. Motivated by the above, we develop an interactive system for Mining and Visualizing Urban Co-locations (MVUC) from the POI datasets of cities.

B. Cui et al. (Eds.): WAIM 2016, Part II, LNCS 9659, pp. 524–526, 2016.
DOI: 10.1007/978-3-319-39958-4

Generally, the main contributions of MVUC can be summarized as:

- Firstly, in order to efficiently mine urban maximal patterns, the order-clique-based approach which is based on instance-trees is modified [1]. Maximal patterns are mined from bottom to top by Aprior-like method instead of checking candidate patterns generated from 2-size patterns from top to bottom.
- Secondly, MVUC visualizes co-locations including concisely demonstrating the table-instances of patterns on map based on the convex hull algorithm [2, 5], intuitively illustrating areas in which the consequents' instances of rules possibly appear on map based on the intersection of areas, and visually figuring patterns by graph [3]. And MVUC also allows users to compare co-locations in different regions.

2 System Overview

The interactive system for Mining and Visualizing Urban Co-locations (MVUC) mainly includes 4 modules shown in Fig. 1.

- **Input Module:** In this module, users can select the POI datasets of cities or regions, set the thresholds including the distance threshold *d*, the participation index threshold *pi*, and the conditional probability threshold *cp*.

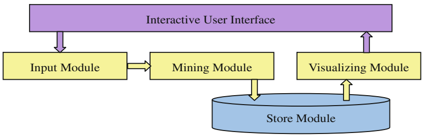
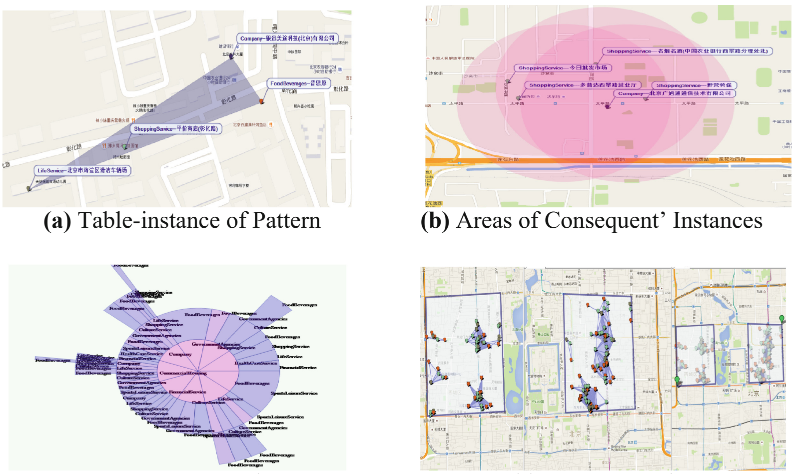


Fig. 1. System overview of MVUC



(a) Table-instance of Pattern **(b)** Areas of Consequent' Instances

(c) Pattern Graph **(d)** Multi-map Comparison

Fig. 2. Demonstration scenario of MVUC

- **Mining Module:** This module mines urban maximal patterns and rules. We modify the order-clique-based approach which is based on instance-trees in order to efficiently mine patterns. The order-clique-based approach generates initial candidate patterns which are maximal cliques of features in 2-size patterns, and then generates successive candidate patterns from the top down [1]. However, our approach adopts Aprior-like method to find urban maximal patterns from the bottom up.
- **Store Module:** In this module, patterns and rules are stored in files.
- **Visualizing Module:** This module includes 4 sub-modules. **(a) Demonstrating the table-instances of patterns on map.** A row-instance in the table-instance is a clique in which any two nodes have edges. In order to concisely demonstrate a row-instance, we use the convex hull algorithm to reduce unnecessary edges of a clique and get an area as Fig. 2(a) shows [2, 5]; **(b) Illustrating areas in which the consequents' instances of rules possibly appear on map.** The consequents' instances and the antecedents' instances should be located in a spatial neighborhood, so we compute the areas by the intersection of areas which are the neighborhoods of the antecedents' instances for intuitively illustrating the areas as Fig. 2(b) shows; **(c) Figuring patterns by graph.** We adopt the radiate hierarchy graph to visually figure patterns as Fig. 2(c) shows [3]; **(d) Co-locations comparison.** This is a multi-map comparison sub-module as Fig. 2(d). It allows users to explore commonness and divergences among co-locations from different regions.

3 Demonstration Scenario

In this section, we select the POI dataset of Beijing as the demonstration scenario of MVUC [4]. In Fig. 2(a) shows a row-instance in the table-instance of 4-size pattern {*company*; *shopping service*; *food service*; *life service*}; (b) shows the areas in which the consequent of rule {*company life service*}→{*shopping service*} possibly appear; (c) figures all patterns in Beijing; and (d) shows exploration for differences in spatial distribution of pattern{*life service; shopping service; food service*} between areas in the west and east of the Forbidden City by multi-map comparison.

Acknowledgments. This work is supported by the National Natural Science Foundation of China (61262069, 61472346), the Natural Science Foundation of Yunnan Province (2015FB114), and Innovation and Entrepreneurship Training Program for College Students in Yunnan Province (106732015010).

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