Chapter 42
ConChi:
Pattern Change Mining from Mobile Context-Aware Data

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ABSTRACT

Mobile context-aware systems focus on adapting mobile service provisions to the actual user needs. They offer personalized services based on the context in which mobile users' requests have been submitted. Since contextual information changes over time, the application of established itemset change mining algorithms to context-aware data is an appealing research issue. Change itemset discovery focuses on discovering patterns which represent the temporal evolution of frequent itemsets in consecutive time periods. However, the sparseness of the analyzed data may bias the extraction process, because itemsets are likely to become infrequent at certain time periods. This chapter presents ConChI, a novel context-aware system that performs change itemset mining from context-aware data with the aim at supporting mobile expert decisions. To counteract data sparseness itemset change mining is driven by an analyst-provided taxonomy which allows analyzing data correlation changes at different abstraction levels. In particular, taxonomy is exploited to represent the knowledge that becomes infrequent in certain time periods by means of high level (generalized) itemsets. Experiments performed on real contextual data coming from a mobile application show the effectiveness of the proposed system in supporting mobile user and service profiling.

INTRODUCTION

Context-aware mobile systems are advanced decision-making systems that analyze the context under which user requests have been submitted through their mobile devices with the goal of adapt service provision to the actual user needs (Bradley et al., 2005; Jameson, 2001). Depending on the circumstantial factors or the application context in which users are involved, the context-aware system allows experts to personalize service offers and promotions and, thus, improve the quality of the offered services. Furthermore, context-aware system may be useful for performing service re-source shaping. For instance, in a mobile context, service bandwidth shaping may be driven by the

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analysis of the temporal and spatial information associated with the submitted user requests.

The use of machine learning techniques (e.g., rule induction, Bayesian networks) or data mining techniques (e.g., classification algorithms) in context-aware data analysis is established. For instance, contextual data has already been exploited to learn accurate predictive user models (Oliver et al., 2004; Tapia et al., 2004) and user profiles (Nurmi et al., 2006). More recently, reasoning techniques and association rule mining algorithms have been applied to discover patterns that represent potentially actionable knowledge (Baralis et al., 2011; Strobbe et al., 2012).

The continuous evolution of contextual data over time prompts the need of novel data mining approaches able to discover significant temporal pattern changes. Change pattern mining (Agrawal & Psaila, 1995) entails discovering patterns, i.e., itemsets or association rules (Agrawal et al., 1993), that (i) frequently occur in data collected within each time period (i.e., their corresponding support values exceed a given threshold), and (ii) may change, in terms of their main quality indexes, from one time period to another. The history of the main pattern quality indexes reflects the most relevant temporal data correlation changes. However, applying traditional change pattern mining algorithms to a sequence of timestamped contextual data collections is a challenging task. In fact, when analyzing a sequence of consecutive time periods potentially useful patterns discovered from the service request logs are likely to occur rarely in at least one of them. Hence, the information associated with the discovered patterns may be lost, unless lowering the minimum support threshold and extracting a huge amount of other (potentially redundant) patterns.

This Chapter presents ConChI (Context-aware Change mIner), a mobile context-aware system that performs pattern change analysis in order to support mobile data analysis. The system focuses on discovering useful change patterns, which represent the most significant contextual data correlation changes. In particular, ConChI first collects contextual information relative to the service requests submitted to the mobile application in different time periods and integrates them in common data repositories. Then, itemset change mining is performed by exploiting the recently proposed HiGen Miner algorithm (Cagliero, 2011), which discovers the History Generalized Patterns (HiGens). HiGens represent the evolution of itemsets in consecutive time periods. To avoid discarding rare but potentially relevant knowledge, itemsets that become infrequent in a certain time period with respect to the minimum support threshold are generalized at a higher level of abstraction by exploiting an analyst-provided taxonomy (i.e., a set of is-a hierarchies built on data items). A generalized version of a traditional itemset (i.e., a generalized itemset) is a pattern that represents the same knowledge at a higher level of aggregation according to a given taxonomy (Agrawal & Srikant, 1995). Hence, the knowledge associated with itemsets that occur rarely at certain time periods is still maintained by replacing the low level itemsets with their frequent generalizations with the least abstraction level.

The usefulness of the change patterns discovered from context-aware data coming from a real-life mobile application has been experimentally validated by a domain expert. The mined HiGens are deemed particularly useful by domain experts for supporting knowledge discovery targeted to user and service profiling.

This Chapter is organized as follows. Section "Previous works" compares our work with recent related approaches. Section "The ConChI System" presents the architecture of the proposed system and thoroughly describes its main blocks. Section "Experimental evaluation" assesses the effectiveness of the proposed system in supporting knowledge discovery from mobile context-aware data. Section "Future research directions" presents future development of this work, while Section "Conclusions" draws conclusions.