Chapter 14
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

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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
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 min-
ing techniques (e.g., classification algorithms) in context-aware data analysis is established. For in-
stance, 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 rep-
resent 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 informa-
tion 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 context
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 generaliza-
tions 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