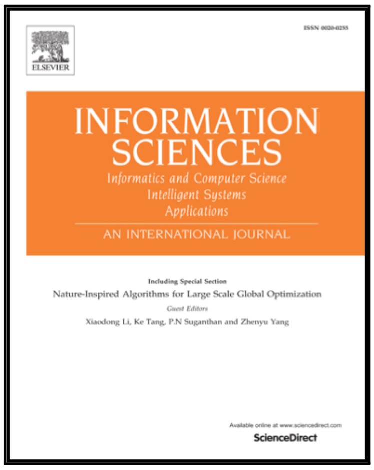
Accepted Manuscript



Mining Temporal Characteristics of Behaviors from Interval Events in E-learning

Tao Xie, Qinghua Zheng, Weizhan Zhang

PII: S0020-0255(18)30199-3
DOI: 10.1016/j.ins.2018.03.018
Reference: INS 13496

To appear in: *Information Sciences*

Received date: 25 July 2017
Revised date: 3 March 2018
Accepted date: 9 March 2018

Please cite this article as: Tao Xie, Qinghua Zheng, Weizhan Zhang, Mining Temporal Characteristics of Behaviors from Interval Events in E-learning, *Information Sciences* (2018), doi: 10.1016/j.ins.2018.03.018

Mining Temporal Characteristics of Behaviors from Interval Events in E-learning☆

Tao Xie, Qinghua Zheng, Weizhan Zhang

College of Computer and Information Science, Southwest University, Chongqing, 400715 China

Abstract

Much of the work in the data mining community mines temporal knowledge based primarily on the frequency of events, e.g., frequent pattern mining, ignoring their duration. This paper discusses a method that mines big learning data by taking both the frequency and duration into account. It defines a function for evaluating the importance of events, summarizing them into big uniform events (BUEs) according to the semantics, and further segmenting the BUEs using a sliding window to avoid the counting bias issue. The task of finding temporal characteristics is eventually reduced to mining complex temporally frequent patterns and association rules. To validate this method, a series of extensive experiments are conducted on both synthetic and real datasets to test the system overhead, quality of patterns, and model parameters. The results show that our mining framework is serviceable and can effectively improve the quality of patterns.

Keywords: Temporal data mining, temporal characteristics, interval events, e-learning

1. Introduction

Information technology has changed the way in which people live and work. In addition, it has a significant influence on the educational domain. Currently, e-learning plays an increasingly important role. Most e-learning systems are capable of keeping detailed logs of user interactions, including keyboard clicking, eye tracking, and video browsing. These data create new opportunities for learning how students behave.

As an operation occurs, an e-learning system instantly records the corresponding interactive event. An event corresponds to a specified event type, which usually has a starting point, an end point, and a list of attributes that describe the event [39]. Educators may need to find the temporal characteristics of individuals' behaviors to gain further insight into their learning habits, preferences, and cognitive efforts over time [4]. However, this task is not easy to accomplish, as we typically are not able to obtain obvious cues from massive and fragmented events. These cues include detecting important events (*IE*s) and their temporal relations. These IEs and relations are both desired because the former represent particular preferences and habits, while the latter represent certain causal associations or temporal patterns. This paper aims to provide knowledge to system designers, teachers, leaders, and students that enables them to understand how individuals behave over time; moreover, it seeks to provide, for the first time, evidence supporting the promotion of certain *IE*s and temporal relations in human-computer interaction design.

The temporal characteristics characterize not only when and what type of behavior a student engages in but also cases in which behaviors change. A simple example is the case of video-viewing behavior [7, 6]. The authors used limited video clickstream events such as *play* and *pause*. Thus, the temporal characteristics were easy to obtain, as the *play* event indicates the start of a cognitive activity, while the *stop* event indicates the termination of an activity. The temporal characteristics may simply display *play-stop* loops or something similar to *play-play-stop* with different durations. One learns that a student stops watching after three seconds or is probably searching for something as he triggers multiple consecutive *play* events. Moreover, one learns that a student permanently stops watching a video because of disinterest when seven loops occur in succession. In a more complex example, we assume that there are many more events than those considered in the above scenario. Suppose a student browses objects (maybe a video, a PPT, or a structured site) in parallel, as in Fig. 1. He may switch between them, browse multiple times through different parts of one object intermittently, or leave for non-overlapping and uneven temporal durations due to various cognitive demands. Is it possible to address the temporal characteristics of this complex scenario? In other words, can we determine whether an event is important, what the temporal pattern is, and how to characterize it? Unfortunately, we have not found a direct and effective approach to answer these questions.

The traditional approaches treat the groups of consecutive

☆This research was partially supported by the National Science Foundation of China under Grant Nos. 61472317, 61428206, 61221063, 61472315, and 91218301, the MOE-China Mobile Research Fund Project No. MCM20160405, the MOE Innovation Research Team No. IRT13035, the Coordinator Innovation Project for the Key Lab of Shaanxi Province under Grant No. 2013SZS05-Z01, the Online Education Research Foundation of the MOE Research Center for Online Education under Grant Nos. 2016YB165 and 2016YB169, the Natural Science Basic Research Plan in Shaanxi Province of China Nos. 2016JM6027 and 2016JM6080, and the Project of China Knowledge Centre for Engineering Science and Technology.

Email addresses: xietao@swu.edu.cn (Tao Xie), qhzheng@mail.xjtu.edu.cn (Qinghua Zheng), zhangwzh@mail.xjtu.edu.cn (Weizhan Zhang)