Map-based Visual Analytics of Moving Learners

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ABSTRACT

Location-based mobile learning (LBML) is a type of mobile learning in which the learning content is related to the location of the learner. The evaluation of LBML concepts and technologies is typically performed using methods known from classical usability engineering, such as questionnaires or interviews. In this paper, the authors argue for applying visual analytics to spatial and spatio-temporal visualizations of learners’ trajectories for evaluating LBML. Visual analytics supports the detection and interpretation of spatio-temporal patterns and irregularities in both, single learners’ as well as multiple learners’ trajectories, thus revealing learners’ typical behavior patterns and potential problems with the LBML software, hardware, the didactical concept, or the spatial and temporal embedding of the content.

KEYWORDS


INTRODUCTION AND MOTIVATION

The positioning and multimedia capabilities of current mobile devices have given rise to novel learning paradigms that integrate the learner’s position in the didactical concept, thus enhancing learning through the discovery of phenomena in situ. We refer to this kind of learning as location-based mobile learning (LBML) (Brown et al., 2010). Integrated LBML management systems, such as the one presented in Sailer, Kiefer, and Raubal (2015), support the teacher in developing LBML lessons, as well as in the straightforward dissemination of these lessons to the learners’ devices. At the same time, the LBML management system stores the content created by learners on a server, such as geo-tagged photos or textual answers, thus enabling the teacher to track the learning progress and provide individual feedback.

Challenges, however, still exist when using such LBML platforms. Teachers would like to be aware of the learners’ behavior and difficulties in executing the outdoor exercise. These difficulties are mainly caused by environmental variability, unreliable technology, low usability of the system, and by the learners’ and teachers’ background and capabilities (Sailer, Schito, Kiefer, & Raubal, 2015). A careful investigation and evaluation of LBML concepts and platforms is necessary to cope with these challenges.

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We argue here that difficulties in LBML often become apparent in the learners’ spatio-temporal behavior (i.e., their trajectory). A method and tool for the analysis of the learners’ trajectories would help in identifying potential problems occurring during LBML, including those caused by decisions the teacher made during the design of the single learning units. Teachers could, for instance, apply spatio-temporal analyses on a learner’s trajectory to identify problems, such as getting lost, running out of time, visiting incorrect places, or visiting places in an order not intended by the teacher. The relation between spatio-temporal events in the trajectories and the success in completing learning units may help for a better understanding of LBML mechanisms. Consequently, teachers could improve the tasks with respect to the learning goals, the spatio-temporal embedding, or the learning content, leading to improved learning outcomes for future LBML sessions.

The data necessary for this kind of analyses, such as trajectories measured using the Global Positioning System (GPS), can easily be collected with an LBML infrastructure. In general, the broad dissemination of mobile devices has resulted in large amounts of location tracking data, and corresponding analysis methods have been proposed in the Geographic Information Science (GIScience) literature (N. Andrienko, Andrienko, & Gatalsky, 2003). While most analysis methods for trajectories are designed to be performed fully-automated (Y. Zheng & Zhou, 2011), e.g., spatio-temporal data mining (Mamoulis, 2009), analysis methods based on visual analytics take the human analyst into account (semi-automated analysis) (G. Andrienko, Andrienko, & Wrobel, 2007). The underlying assumption of visual analytics is that by combining the strengths of machine (e.g., fast processing and visualization) and human (e.g., visual interpretation and domain knowledge), hypotheses on certain data patterns and on interpretations of these patterns may emerge.

This paper explores the opportunities of using visual analytics to analyze learners’ trajectories for the evaluation of LBML concepts and platforms. We propose that LBML platforms should provide tools that support the visual analysis of one or several learners’ trajectories.

We demonstrate the approach using several example trajectories recorded during different LBML sessions with the OMLETH platform (Sailer, Kiefer, & Raubal, 2015). The trajectories are visualized spatially as overlays on digital maps, as well as spatio-temporally in 3D visualizations. It is discussed how these visualizations may help to contribute to a better understanding of the dynamic process which took place during the learning session.

The following section reviews related work on the evaluation of Learning Management Systems (LMS) and LBML, as well as on trajectory analysis and visual analytics. We then introduce the study design with three different groups learning at two different locations. Using data collected during these learning sessions, it is then described how trajectory analyses can be utilized to evaluate LBML. The paper concludes with a discussion and an outlook on future work.

RELATED WORK

This section provides an overview of the literature on evaluating learning management systems (LMS) and LBML, as well as of methods for trajectory analysis of moving objects, including techniques for visual analytics of spatio-temporal data and map-based representation of space-time data in two and three dimensions.

Evaluation of Learning Management Systems

According to Szabo (2002), an LMS can be seen as a framework that unites and manages all aspects of the learning process. This framework yields several types of functions such as instructional content management, learning or training goal assessment, learning progress tracking and reporting of its data, as well as supervising the complete learning process. One important benefit of an LMS is the opportunity of providing lessons based on the individual student’s learning progress (Szabo, 2002).

With the evolutionary growth of both, LMS and the tracking of students’ performance, large data collections have become available. A similar evolution of growing datasets (often referred to as
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