

ISEQL, an Interval-based Surveillance Event Query Language

Sven Helmer, Free University of Bozen-Bolzano, Bolzano, Italy

Fabio Persia, Free University of Bozen-Bolzano, Bolzano, Italy

ABSTRACT

The authors propose ISEQL, a language based on relational algebra extended by intervals for detecting high-level surveillance events from a video stream. The operators they introduce for describing temporal constraints are based on the well-known Allen's interval relationships and we implemented on top of a PostgreSQL database system. The semantics of ISEQL are clearly defined, and the authors illustrate its usefulness by expressing typical events in it and showing the promising results of an experimental evaluation.

KEYWORDS

Event Query Languages, High-Level Event Detection, Intervals, Surveillance, Video Stream

INTRODUCTION

For the detection of certain behavioral or other patterns low-level events are usually not very useful. For example, when trying to identify the exchange of a package or an item of luggage at a train station using a video surveillance system, we have hundreds or thousands of people carrying items appearing in the video footage. Consequently, just checking the presence of persons and items is not sufficient, we are interested in specific sequences of events, such as person A carrying item X, setting it down and leaving, and finally person B picking up X. Deriving knowledge on a higher level from low-level events by combining the latter to complex structures is the task of *an event query language (EQL)*.

An issue of many current EQLs is the lack of formal semantics (Eckert, 2011). In our approach we propose *ISEQL*, a language based on relational algebra for detecting high-level events. The relational algebra is clearly defined and forms the basis for many database query languages such as SQL. Additionally, this allows us to tap into the results of database research, such as optimizing the execution of relational algebra expressions by rewriting them. Relational databases are also widespread, which means that developers and users who are familiar with these systems have no problems in understanding the basic concepts of our language.

Using relational algebra as a foundation for an EQL is not a completely new idea (Eckert, 2011; Arasu 2006). The novelty of our approach is mapping the concepts of event detection to a relational algebra extended by interval operators based on *Allen's interval relationships* (Allen, 1983). More and more database vendors integrate interval or range types and operators into their systems (PostgreSQL manual; Temporal tables), which allows us to re-use some of this functionality. These operators make it much easier to handle temporal constraints directly instead of modeling them in the traditional relational model. In summary, we make the following contributions:

- We define an *Interval-based Surveillance Event Query Language (ISEQL)* based on relational algebra extended by interval operators.

DOI: 10.4018/IJMDEM.2016100101

- We illustrate how *ISEQL* can be used to detect high-level events in a video surveillance context.
- We describe in detail the framework developed for event detection.
- A brief experimental study using real-world data sets shows that queries in *ISEQL* can be evaluated efficiently.

The remainder of the paper is organized as follows. In the next section we cover related work and in Section 3 we give an overview of the proposed framework and a formal description of the low-level and medium-level events. Section 4 defines the medium-level events with interval relations and introduces the operators of our extended relational algebra, while Section 5 illustrates how to use these operators to detect high-level events. In Section 6, we describe in detail the overall framework developed for event detection. This is followed by an experimental evaluation investigating the accuracy and run time of our approach. Finally, Section 8 concludes the paper.

RELATED WORK

There is a substantial body of work on searching for specifically defined patterns of activities in a video surveillance context (Hongeng, 2001) using stochastic automata: Vaswani (2005) studies *Hidden Markov Models* (HMMs), Brand (1997) and Oliver (2002) use coupled HMMs, Hamid (2003) employs *Dynamic Bayesian Networks* (DBNs) to capture causal relationships between observations and hidden states, Albanese (2007) develops a stochastic automaton-based language, and Cuntoor (2008) presents an HMM-based algorithm.

Moreover, Albanese (2013) proposes an indexing technique for temporal stochastic automaton-based activity models and then go on to find observation sequences that are not sufficiently explained by models within an initial set of predefined innocuous and dangerous activities (Albanese, 2011; Albanese, 2014). Potentially, our technique could be combined with this approach to update and extend the event knowledge base of models.

One major drawback of event detection approaches based on *nondeterministic finite automata* (NFA) is the representation of negation, especially when there are predicates involving negated and non-negated events. It is also hard to support concurrent events, such as conjunctive queries (e.g., events *A* and *B* occurring simultaneously), in an NFA-based model because of explicitly ordered state transitions. Our approach has no issues related to negation or conjunctive queries. Also, the evaluation order in the NFA-based approaches is fixed and determined by a state transition diagram. Usually, queries are evaluated by performing *backward search* starting from the final state. In our case, we can exploit well-known database query optimization techniques to make the execution of queries faster.

Since the terminology used in the area of event detection is not always consistent, relevant work can also be found under the heading *Complex Event Processing* (CEP). Cugola (2010; 2012) presents TESLA (Trio-based Event Specification LAnguage), which provides a simple and compact syntax, while offering high expressiveness and flexibility. It supports content-based event filtering and allows the capture of complex relations among temporally related patterns of events. TESLA is among the first languages for CEP to offer a formal semantics expressed in terms of temporal logic. Mei (2009) develops ZStream, a high-performance CEP system designed and implemented for efficiently processing sequential patterns. ZStream is also able to support relations such as conjunction, disjunction, negation, and the Kleene closure. However, compared to our approach, Cugola (2010; 2012) and Mei (2009) have certain limitations in terms of expressing very complex rules involving several sub-events. Furthermore, Eckert (2011) proposes the Complex Event Relational Algebra (CERA), which is able to represent execution plans for complex event queries in an extended version of the relational algebra. They also show how XChangeEQ (Bry, 2010), a high-level EQL, can be mapped to CERA. Of all the approaches discussed so far, CERA comes closest to ours. However, whereas our approach offers the full spectrum of Allen's interval relationships extended with (optional) thresholds, CERA only provides generic temporal operators for overlapping events.

19 more pages are available in the full version of this document, which may be purchased using the "Add to Cart" button on the product's webpage:

www.igi-global.com/article/iseql-an-interval-based-surveillance-event-query-language/170569?camid=4v1

This title is available in InfoSci-Journals, InfoSci-Journal Disciplines Communications and Social Science, InfoSci-Select, InfoSci-Communications, Online Engagement, and Media eJournal Collection, InfoSci-Knowledge Discovery, Information Management, and Storage eJournal Collection, InfoSci-Networking, Mobile Applications, and Web Technologies eJournal Collection, InfoSci-Surveillance, Security, and Defense eJournal Collection, InfoSci-Journal Disciplines Engineering, Natural, and Physical Science.

Recommend this product to your librarian:

www.igi-global.com/e-resources/library-recommendation/?id=2

Related Content

Wireless Video Transmission

Supavadee Aramvith and Rhandley D. Cajote (2009). *Handbook of Research on Secure Multimedia Distribution* (pp. 211-240).

www.igi-global.com/chapter/wireless-video-transmission/21315?camid=4v1a

Discrete Transform Based Image Fusion: A Review

Umesh Kumar, Neha Gopaliya, Uma Sharma and Sandeep Gupta (2017).

International Journal of Multimedia Data Engineering and Management (pp. 43-49).

www.igi-global.com/article/discrete-transform-based-image-fusion/178933?camid=4v1a

Accurate Image Retrieval with Unsupervised 2-Stage k-NN Re-Ranking

Dawei Li and Mooi Choo Chuah (2016). *International Journal of Multimedia Data Engineering and Management* (pp. 41-59).

www.igi-global.com/article/accurate-image-retrieval-with-unsupervised-2-stage-k-nn-re-ranking/149231?camid=4v1a

Navigating Through Video Stories Using Clustering Sets

Sheila M. Pinto-Cáceres, Jurandy Almeida, Vânia P. A. Neris, M. Cecilia C. Baranauskas, Neucimar J. Leite and Ricardo da S. Torres (2011). *International Journal of Multimedia Data Engineering and Management* (pp. 1-20).

www.igi-global.com/article/navigating-through-video-stories-using/58048?camid=4v1a