Nondeterministic Temporal Relations in Multimedia Data

Li Minglu (~Li Minglu~), Sun Yongqiang (~Sun Yongqiang~) and Sheng Huanye (~Sheng Huanye~)

Department of Computer Science and Engineering, Shanghai Jiao Tong University
Shanghai 200030

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Abstract

Synchronization is an important issue in multimedia systems which integrate a variety of temporally related media objects. One part of synchronization is the representation of temporal information. With the emerging interactive multimedia, deterministic temporal models are replaced by nondeterministic ones with more expressiveness. This paper classifies temporal models by their expressiveness, and evaluates relevant nondeterministic temporal relations in multimedia data. Additionally, an interval-based nondeterministic model based on a complete temporal operator set is proposed providing high-level abstractions and a high degree of expressiveness for interactive multimedia systems.

Keywords: Multimedia systems, synchronization, temporal models, temporal relation, information representation.

1 Introduction

Multimedia systems integrate a variety of media with different temporal characteristics, e.g. time dependent media, such as audio, video, and animation, and time independent media, such as text, graphics, and images[1]. In monomedia environments, all media show the same basic temporal behavior. Time does not get any particular attention. Now, with the arising multimedia systems, various temporal relations between media objects become more and more important.

Assuring the correct temporal appearance of the media objects is called synchronization[2]. This issue of synchronization is twofold. First, the temporal appearance including the relations of presentation objects has to be specified. The temporal specification has to be represented for reviewing by the user, presentation planning by the system and storing purposes. Secondly, the multimedia system has to guarantee the temporal constraints when presenting the media objects. This paper focuses on the first issue of representing temporal relations in multimedia data.

To represent temporal relations between multimedia presentation objects temporal abstractions are needed. A set of temporal abstractions is called temporal model in this paper. In any specific context, it is desired that all multimedia scenarios are representable by temporal model. A temporal model is complete in a context if all scenarios are expressible within the model. A number of temporal models have been
proposed by various authors. To decide whether they are appropriate for multimedia or not, all scenarios would have to be enumerated in all contexts. Since this is not possible, we chose a different approach. In Section 2, a summary of all temporal relations is given, and the question “Which out of all possible temporal relations might be needed for multimedia?” is examined.

Analyzing the temporal models, we found that interval-based models generally do not use all interval relations although interval relations represent higher-level abstractions than point-based relations. So, we have developed in Section 3 a complete operator set to represent a set of relevant nondeterministic interval relations. Finally, some concluding remarks are given in Section 4.

2 Temporal Relations in Multimedia Data

To systematically develop a complete set of temporal relations for multimedia, we examine how many and which relations are theoretically possible. Depending on their elementary units, two basic classes of temporal models can be distinguished. In the first class, time is expressed by means of points in a one-dimensional time space, whereas in the second model class, intervals are the atomic units of the time space. This section introduces the temporal models, their elementary units and the relations between them, and evaluates the relevant temporal relations in multimedia data.

2.1 Point-Based Model

In point-based temporal model, the elementary units are events, which are points in a time space. Given two events in history, only three relations can hold between them. An event can be before (<), simultaneous to (=) or after (>) a second event. The relations <, =, > are called the basic point relations.

In contrast to relations in the past, relations between future events might be indefinite. For example, we know that an event e1 cannot occur after an event e2. This means that e1 is before or simultaneous to e2. This is denoted as e1 < e2 ∨ e1 = e2 or as e1{<, =}e2. Note that e1 is before or simultaneous to e2, and it is not known which of the relations will become true. Typically, indefinite relations are represented as disjunctions of basic point relations. Since there are three basic point relations, 2^3 = 8 disjunctions exist each representing an indefinite relation. For example, instead of e1{<, =}e2, we use e1 ≤ e2. The eight indefinite relations are: ∅, ≤, <, =, >, ≥, ≠, ?, where '?' is the full set of basic point relations {<, =, >}, ∅ is the empty set { }, and the others are self-explaining. Therefore, the basic point relations are a subset of the indefinite point relations.

2.2 Interval-Based Model

Intervals are the basic units of a time model class suggested by [5]–[7]. There are 13 basic interval relations. Table 1 summarizes the 13 basic interval relations showing the name, the symbol, and the inverse. In this context, a and b represent intervals. Also, a point notation exists for each interval relation. It is given in the fourth column with Sa denoting the starting and Ea the end of the interval a.