Towards a Flexible Visualization Tool for Dealing with Temporal Data

Guy de Tré[1], Nico Van de Weghe[2], Rita de Caluwe[1], and Philippe De Maeyer[2]

[1] Department of Telecommunications and Information Processing, Ghent University, Sint-Pietersnieuwstraat 41, B-9000 Gent, Belgium
[2] Geography Department, Ghent University, Krijgslaan 281 (S8), B-9000 Gent, Belgium
Guy.DeTre@telin.ugent.be

Abstract. Time plays an important role in our everyday's life. For a lot of observations we make and actions we perform, temporal information is relevant. The importance of time is reflected in the development of information systems such as (temporal) database systems and data warehouse systems, which have facilities to cope with temporal data and usually manage huge collections of historical data. It is a challenge to develop intuitive user interaction tools that allow users to fully explore these collections of temporal data. With this paper, we want to contribute to the development of such a tool. The presented approach is based on a visualization of time intervals as points in a two-dimensional space and on temporal reasoning based on this visualization. Flexibility is provided by allowing to cope with imperfections in both the modelling of time and the temporal reasoning.

Keywords: Time modelling, user interfaces, fuzzy set theory.

1 Introduction

The central role of temporality in many computer applications makes the representation, manipulation and visualization of temporal information highly relevant.

Related to database systems and data warehouse systems, several time models for the representation and manipulation of time have been proposed, each having its own applicability and limitations. Research on temporal models is in general motivated by the observation that most databases and data warehouses contain substantial amounts of temporal data, what makes that specific modelling and management techniques for temporal data are a requirement for an efficient exploitation of these data collections [7]. An interesting bibliographic overview of older work can be found in [13]. More recent work and state of the art are summarized in [12, 4]. There have also been some efforts to bring into line the resulting diversity of concepts and terminology [6].

Almost of equal importance, is research on the visualization of temporal data [9, 8, 10, 2]. As time is usually modelled using a one-dimensional time space, visualization of large amounts of temporal data tends to result in an overwhelming

H. Legind Larsen et al. (Eds.): FQAS 2006, LNAI 4027, pp. 109–120, 2006.

image of (overlapping) intervals, which lacks clarity and does not provide the user with the insights and overviews that are necessary to fully explore the data. For the sake of illustration of the problem, consider for example the one-dimensional time lines used by historian to represent important dates and periods in history. Such time lines quickly tend to become overloaded with data when more facts are registered.

In this paper, we propose a flexible, alternative approach for the visualization of temporal data. The approach allows for a better human-computer interaction by providing users with a more compact visualization of the temporal data and the temporal relationships that exist between these data. By using the approach, the user should better understand the data and gain new insights, which on its turn should be supportive for the further exploration of the database or data warehouse. Moreover, the presented approach provides some flexibility and allows to deal with possible imperfections of the data (e.g., imprecision, incompleteness, or uncertainty), both at the level of the temporal data modelling and at the level of temporal reasoning. The presented approach is inspired by the work of Z. Kulpa [9, 10] in which a diagrammatic representation for interval arithmetic is presented. Flexibility is provided by applying fuzzy set theory [14].

The remainder of the paper is organized as follows. In Section 2, the basic framework of the visualization approach is described. Both the structural aspects and behavioral aspects are dealt with. The basic framework is generalized in Section 3 in order to be able to cope with imperfections of the data. In Section 4, an illustrative example demonstrating some of the potentials of the approach is presented. Finally, some conclusions are given in Section 5.

2 A Framework for Visualizing Temporal Data

2.1 Some Preliminaries

In this paper, it is implicitly assumed that time is modelled as being *discrete*, *linear* and *finite*. This means first of all that the restriction is accepted that time can only be observed using a limited precision, say Δ. This is not really a limitation, on condition that the precision is chosen sufficiently accurate. Indeed, this restriction results from the way observations and measurements are made and it conforms to the way data can be stored in computers. The discretization is necessary to circumvent the density problem (i.e., the fact that between any two distinct points, there always exists at least one other point). The need for non-linear structures with topologies such as branching time, parallel time, circular time etc. as suggested by some authors [11], is not supported in the model. Linearity implies a total order over the time points. Finally, our model is chosen to be finite in view of a computer representation. This implies that all values that exceed the determined upper and lower bound will be handled by introducing two special values ($-\infty$ and $+\infty$).

Observing time using a maximum precision Δ and with respect to a given origin t_0 involves a crisp discrete (countable) set of time points, given by:

$$T_{0,\Delta} = \{t_k \in T | t_k = t_0 + k\Delta, k \in \mathbb{Z}\}, \text{ where } \mathbb{Z} = \{0, 1, -1, 2, -2, \dots\} \quad (1)$$