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Title: 多媒體簡報時程及佈局的自動產生
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主持人: 施國琛 教授
執行機構及單位名稱: 私立淡江大學資訊工程學系

中文摘要

以時間區段間的關係來建構時間相依的物件，並用代數方式的計算，推導所有多媒體物件間時序上及空間上的關係，發展出一套讓使用者可隨意設計的多媒體簡報系統

關鍵字: 多媒體簡報、時間區段、時空關係、代數系統。

Abstract

The relations among temporal intervals can be used to model time-dependent multimedia objects. We analyze the domains of interval temporal relations. A set of algorithms is proposed to derive reasonable relations between intervals. Possible conflicts in the user specification are firstly detected and eliminated. Composite objects can have arbitrary timing relation-ships. The algorithms are extended for time-based media in an arbitrary n-dimensional space. The contributions of these algorithms and the interval algebra system can be used to process the temporal knowledge query, to generate the schedule and layout of multimedia presentations.

Keywords: Multimedia Presentation, Temporal Interval, Temporal-Spatio Relation, Algebra System

1 Introduction

Communication networks and multimedia appli-cations usually contains a number of resources to be presented sequentially or concurrently. Temporal interval relations represent the timing among resources. These resources need to be analyzed to ensure that there is no time conflict among resources. Moreover, many of these resources, occupy period of time and screen space. These data can be heavily time-dependent, such as audio and video in a motion picture, and can require time-ordered presentation. The spatio-temporal relations among resources need to be computed and represented.

The importance of knowledge underlying temporal interval relations was found in many disciplines. As pointed out in [1], researchers of artificial intelligence, linguistics, and information science use temporal intervals as a time model for knowledge analysis. The work discussed in [1] analyzes the relations among temporal intervals. However, the work [1] only states temporal interval relations. No spatial relation was discussed. We found that these relations can be generalized for spatial modeling. The use of spatio-temporal relations serves as a reasonable semantic tool for the underlying representation of objects in many multimedia applications. Composite objects can have arbitrary timing relationships. These might be specified to achieve some particular visual effect of sequence.

2 The Spatio-Temporal Relation Domains

According to the interval temporal relations introduced in [1], there are 13 relations between two temporal intervals. We describe the symbolic constraint propagation. The general idea is to use the existing information about the relations among time intervals or instants to derive the composition relations.

The composition may result in a *multiple derivation*. For example, if "X before Y " and "Y during Z " , the composed relation for X and Z could be "before", "overlaps", "meets", "during", or "starts". If the composed relation could be any one of some relations, these derived relations are called *reasonable relations* in our discussion.

In some cases, relation compositions may result in a *conflict specification* due to the user specification or involved events synchronously. For example, if specifications " X before Y " ," Y before Z " , and " X after Z " are declared by the user, there exists a conflict between X and Z. When the specific relations are not found in derived reasonable set, the specification may cause conflicts.

For an arbitrary number of objects, some of the relations are specified by the user while others are derived. If there exists a cycle in the directed relation graph, a conflict derivation may occur.

In our project, we develop an O(n)-time algorithm for propagation temporal constraint between two time events. For solving point/interval algebra networks, we develop an O(n^2)-time algorithm that is an O(n) improvement over the previously known algorithm [9] for finding all pairs of feasible relations, where n is the number of points or intervals.

3 The Finite Temporal Relations Group

Based on Allen's work, transitivity table for the twelve temporal relations (omitting "=") showing the composition of interval temporal relations. Compositions of three or more relations are computed using algorithms based on set operations, such as set union and intersection. These set operations are expensive. We calculate Table29, an extension of *Table13* (Allen's Table). The compositions of three or more relations can be obtained directly from our table. *Table29* consists of the compositions of 29 temporal relation sets. Based on the *Table29*, we found many properties of spatio-temporal relations.

A temporal tuple contains two interval names and a relation set. The following table gives a summary of the 29 relation sets, which contain all possible composition results:

Table 1: The 29 Relation Sets

ID	Relation Sets
1	{ < }
2	{ > }
3	{ d }
4	{ di }
5	{ o }
6	{ oi }
7	{ m }
8	{ mi }
9	{ s }
10	{ si }
11	{ f }
12	{ fi }
13	{ e }*
14	{ o, di, fi }
15	{ oi, d, f }
16	{ o, d ,s }
17	{ oi, di, si }
18	{ <, o, m }
19	{ >, oi, mi }
20	{ f, fi, e }*
21	{ s, si, e }*
22	{ <, o, m, d, s }
23	{ >, oi, mi, di, si }
24	{ <, o, m, di, fi }
25	{ > , oi, mi, d, f }
26	{ o, oi, d, di, s, si, f, fi, e }*
27	{ <, m, d, di, o, oi, f, fi, s, si, e }
28	{ > , mi, di , d, oi, o, fi, f , si, s, e }
29	{ < , > ,m, mi, di , d, oi, o, fi, f , si, s, e }*

Table29 is generated by our implemented program.

Table 2 : The Temporal Transitive Closure Table

o	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
01	01	29	22	01	01	02	01	22	01	01	22	01	01	01	22	22	22	01	29	22	01	22	29	01	29	22	22	29	29
02	29	02	25	02	25	02	25	02	25	02	02	02	02	25	25	25	02	29	02	02	25	29	02	29	25	25	29	25	29
03	01	02	03	29	22	25	01	02	03	25	03	22	03	29	25	22	29	22	25	22	25	22	29	29	25	29	29	29	29
04	24	23	26	04	14	17	14	17	14	04	17	04	04	14	26	26	17	24	23	17	14	27	23	24	28	26	27	28	29
05	01	23	16	24	18	26	01	17	05	14	16	18	05	24	26	22	27	18	28	22	14	22	29	24	28	27	27	29	29
06	24	02	15	23	26	19	14	02	15	19	06	17	06	28	25	26	23	27	19	17	25	27	23	29	25	28	29	28	29
07	01	23	16	01	01	16	01	20	07	07	16	01	07	01	16	22	22	01	28	22	07	22	29	01	28	22	22	29	29
08	24	02	15	02	15	02	21	02	15	02	08	08	08	25	25	15	02	27	02	08	25	27	02	29	25	25	29	25	29
09	01	02	03	24	18	15	01	08	09	21	03	18	09	24	15	22	27	18	25	22	21	22	29	24	25	27	27	29	29
10	24	02	15	04	14	06	14	08	21	10	06	04	10	14	15	26	17	24	19	17	21	27	23	24	25	26	27	28	29
11	01	02	03	23	16	19	07	02	03	19	11	20	11	28	25	16	23	22	19	20	25	22	23	29	25	28	29	28	29
12	01	23	16	04	05	17	07	17	05	04	20	12	12	14	26	16	17	18	23	20	14	22	23	24	28	26	27	28	29
13	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
14	24	23	26	24	24	26	24	17	14	14	26	24	14	24	26	27	27	24	28	27	14	27	29	24	28	27	27	29	29
15	24	02	15	29	27	25	24	02	15	25	15	27	15	29	25	27	29	27	25	27	25	27	29	29	25	29	29	29	29
16	01	23	16	29	22	28	01	23	16	28	16	22	16	29	28	22	29	22	28	22	28	22	29	29	28	29	29	29	29
17	24	23	26	23	26	23	14	23	26	23	17	17	17	28	28	26	23	27	23	17	28	27	23	29	28	28	29	28	29
18	01	29	22	24	18	27	01	27	18	24	22	18	18	24	27	22	27	18	29	22	24	22	29	24	29	27	27	29	29
19	29	02	25	23	28	19	28	02	25	19	19	23	19	28	25	28	23	29	19	23	25	29	23	29	25	28	29	28	29
20	01	23	16	23	16	23	07	23	16	23	20	20	20	28	28	16	23	22	23	20	28	22	23	29	28	28	29	28	29
21	24	02	15	24	24	15	24	08	21	21	15	24	21	24	15	27	27	24	25	27	21	27	29	24	25	27	27	29	29
22	01	29	22	29	22	29	01	29	22	29	22	22	22	29	29	22	29	22	29	22	29	22	29	29	29	29	29	29	29
23	29	23	28	23	28	23	28	23	28	23	23	23	23	28	28	28	23	29	23	23	28	29	23	29	28	28	29	28	29
24	24	29	27	24	24	27	24	27	24	24	27	24	24	24	27	27	27	24	29	27	24	27	29	24	29	27	27	29	29
25	29	02	25	29	29	25	29	02	25	25	25	29	25	29	25	29	29	29	25	29	25	29	29	29	25	29	29	29	29
26	24	23	26	29	27	28	24	23	26	28	26	27	26	29	28	27	29	27	28	27	28	27	29	29	28	29	29	29	29
27	24	29	27	29	27	29	24	29	27	29	27	27	27	29	29	27	29	27	29	27	29	27	29	29	29	29	29	29	29
28	29	23	28	29	29	28	29	23	28	28	28	29	28	29	28	29	29	29	28	29	28	29	29	29	28	29	29	29	29
29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29

4 Maintaining Time Constraints

Based on *Table29*, we propose a set of algorithms, using a directed graph, for fast temporal relation compositions. These algorithms can be used to compute the binary relation between an arbitrary pair of intervals.

If there is a conflict cycle in the original reduced relation domain, the algorithm eliminates that conflict first. This conflict elimination is achieved by invoking the *EliminateConflict* algorithm. Suppose G is a graph of the reduce relation domain, and GV and GE are the vertex set and edge set of G. The algorithm computes derived edges based on user edges.

Algorithm : *ComputeRD1*
Input : $G = (GV, GE)$
Output: $K_n = (K_nV, K_nE)$
Preconditions : true
Postconditions : $GV = K_nV \wedge GE \setminus UE \cup UE' \subseteq K_nE$
Steps :
1 : G = *EliminateConflicts* (G)
2 : $K_n = G \wedge pl = 2$
3 : repeat until $| K_nE | = | K_nV | * (| K_nV | -1) / 2$
  3.1 : for each $e = (a, b) \wedge e \notin K_nE \wedge a \in K_nV \wedge b \in K_nV \bullet$
  there is a path of user edges from a to b , with path length $= pl$
  3.2 : suppose $((n_1, n_2), (n_2, n_3),\ldots, (n_{k-1}, n_k))$ is a path with $a = n \wedge b = n \wedge k = pl + 1$
  3.3 : set $e.rs$ = *Table29* $((a, n_{k-1}).rs, (n_{k-1}, b).rs)$
  3.4 : $K_nE = K_nE \cup \{ e \}$
  3.5 : $pl = pl + 1$

The first algorithm, *ComputeRD1*, starts from taking each path of user edges of length 2, and computes a derived edge from that path. The insertion of edge $e = (a, b)$ results a cycle, but no conflict.

Algorithm : *EliminateConflicts*
Input : $G = (GV, GE)$
Output : $G' = (GV, G\mathcal{E})$
Preconditions : G contains only user edges $\wedge G' = G$
Postconditions : $G' = G$, but the reasonable sets of edges in G' may be changed.

Steps :

1. for each $P = ((n_1, n_2), (n_2, n_3), \ldots, (n_{k-1}, n_k))$ in G' with $n_1 = n_k \wedge k > 3$
   - 1.1 : for each i, $1 \le i \le k-2$
     - 1.1.1 : set $(n_i, n_{i+2}).rs = Table29\ ((n_i, n_{i+1}).rs, (n_{i+1}, n_{i+2}).rs)$
   - 1.2 : $rs = Table29\ ((n_k, n_{k-2}).rs, (n_{k-2}, n_{k-1}).rs)$
   - 1.3 : if $(n_k, n_{k-1}).r \notin rs$ then
     - 1.3.1 : ask user to choose a $r' \in rs$
     - 1.3.2 : set $(n_k, n_{k-1}).r = r'$

5 Extended Spatial Relations

Let rs denote a set of 1-D temporal interval relations (i.e., $rs \in 29Relset$). The relation composition table can be refined to a function maps from the Cartesian product of two rs to a rs. Assuming that f^1 is the mapping function, we can compute f^2, the relation composition function of 2-D objects, and f^3, the one for 3-D objects, from f^1. There are 13 relations for 1-D objects. A conjunction of two 1-D relations, which denotes a 2-D relation, has 13^2 variations. Similarly, there are 13^3 3-D relations.

$$f^1 = 29RelSet \times 29RelSet \to 29RelSet$$

$$f^2 = 29RelSet \times 29RelSet \times 29RelSet \times 29RelSet \to 29RelSet \times 29RelSet$$

$$f^3 = 29RelSet \times 29RelSet \times 29RelSet \times 29RelSet \times 29RelSet \times 29RelSet \to 29RelSet \times 29RelSet \times 29RelSet$$

where $29RelSet \times 29RelSet \in \{ \{<\} \times \{<\}, \{<\} \times \{>\}, \ldots, \{=\} \times \{=\} \}$

$29RelSet \times 29RelSet \times 29RelSet \in \{ \{<\}\times\{<\}\times\{<\}, \{<\}\times\{<\}\times\{>\}, \ldots, \{=\}\times\{=\}\times\{=\}\}$

Functions f^2 and f^3 are computed according to the following formulas :

$$\forall\, i_1 \times j_1, i_2 \times j_2 \in \mathrm{P}\,(29RelSet \times 29RelSet)$$

$$f^2\,(i_1 \times j_1, i_2 \times j_2) = \prod f^1\,(i_1, i_2) \times f^1\,(j_1, j_2)$$

$$\forall\, i_1 \times j_1 \times k_1, i_2 \times j_2 \times k_2 \in \mathrm{P}\,(29RelSet \times 29RelSet \times 29RelSet)$$

$$f^3\,(i_1 \times j_1 \times k_1, i_2 \times j_2 \times k_2) = \prod f^1\,(i_1, i_2) \times f^1\,(j_1, j_2) \times f^1\,(k_1, k_2)$$

where $\prod A \times B = \{ a \times b \mid \forall a \in A, b \in B \}$

$\prod A \times B \times C = \{ a \times b \times c \mid \forall a \in A, b \in B, c \in C \}$

6 The Applications and Conclusions

Spatio-Temporal relations can be used in many multimedia applications.

As long as the spatial relations of objects are decided, the algorithm can compute the location of each presentation resource in a window.

Moreover, Spatio-Temporal relations can be used to compose objects in multimedia documents [2]. Our mechanism can be incorporated with an object-oriented mechanism [3] for the construction of multimedia presentations. Multimedia resources are not used along usually. Instead, they have some degree of associations. Similarly, multimedia resources, when they are presented, may have some default relative positions. In an application, the presentation system can use our algorithms to compute the schedule of a presentation. Also, in natural language processing, temporal intervals are used to model the timing of events. Our algorithms thus can be used in constructing semantics of sentences. We believe that, spatio-temporal relations can be used in many related applications for maintaining time constraints.

The algorithm proposed in this paper can be used in other computer applications. We hope that, with our analysis and algorithms, the knowledge underlying spatio-temporal relations can be used in many computer applications, especially in multimedia computing.

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