A Novel Multimedia Data Model Supporting Temporal Semantic Abstraction [1]

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Abstract: Most of researches on content descriptions and queries of temporal features only base on the thirteen kinds of temporal relationships defined by Allen, which are difficult to answer the queries of multimedia data that are built on temporal semantic abstraction. Based on the definition of Multimedia Object and Multimedia Data Unit (MDU), this paper focuses on the descriptive algorithm of generalization and aggregation, which are two kinds of important temporal semantic abstraction.

1 Introduction

Temporal feature is one of the most important features in multimedia data. The multimedia database should be able to provide detailed descriptions to such information.

2 Related Works

Many works have been done in order to introduce temporal features into the multimedia data model. Time line uses absolute time to annotate temporal features of media objects in time axis. Breiteneder proposed a model based on time line [BR92], which can distinct differentiation in expressive scene and transmitted time. However, it does not have related description for temporal relationship, either introduces temporal abstraction.

The temporal complicacy of media objects is represented in comparative temporal relationship. For example, there exist many temporal relationships in video object, such as before, after, overlaps, equals and so on. Allen has concluded thirty correlations in two temporal intervals [AL83].

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For the point of view of application, Schloss has discussed a method to build layered model multimedia data [SC94], and proposed a method to operate temporal relation through calculations of multimedia event. Little in [LI93] has proposed TIB (Time-Interval-Based model), which not only describes absolute temporal intervals in object, but also describes relative temporal relationships. Continuous research in [AM99] discusses the queries in temporal intervals when there exists disconnection in temporal intervals. According to the rich semantic queries of multimedia temporal/spatial features, Megalou proposed a method for multimedia temporal/spatial semantic abstraction [ME03]. Although this work provided an operable semantic model for temporal/spatial semantic abstractions, it is difficult to use this model to do everything.

In [YA04], our multimedia data model, which can provide a higher abstraction level, is designed. And this model cans provide a comprehensive description for multimedia content information, such as physics features, structure features and semantic features. Based on this, in this paper, this paper focuses on the descriptive algorithm of generalization and aggregation, which are two kinds of important temporal semantic abstraction.

3 The MDU Data Model

3.1 Multimedia Object

A multimedia object, which describes a meaningful section of multimedia data, can be identified by one of the elements in identification set *ID*. *ID* is a countable and infinite set. The attributes of an object are used to describe the features of the object. Temporal attributes should be able to describe the temporal features of this part of multimedia data. describing by the attributes of temporal interval, which describes the place where this object is in the temporal interval.

Temporal interval domain *T* is defined as a set of tuples, one of which looks like (t_1,t_2). Here, t_1 and t_2 are integers and $t_1 \leq t_2$, which represents the time that the object appears and disappears in the temporal axis, respectively. The values of t_1 and t_2 are the absolute time points of temporal feature. Any object, which have temporal constraints, own a special attribute, which is temporal interval attribute *I*, and the value of this attribute is an element in *T*, (t_s ,t_e).

Let's write $A=\{a_1, a_2, \ldots, a_n\}$ for a set of all possible attributes of all the objects, and write *V* for the value set, which is consisted of all the elements subsets in $C \cup ID \cup T$. Here, *C* is a set of constants, and $C \in 2^{\aleph} \cup 2^{\Re} \cup 2^{\Im}$. Here, $\aleph$ is the set of all possible natural numbers, $\Re$ is the set of all possible real numbers, and $\Im$ is the set of all possible characters.

Definition 1. A **Multimedia Object**, *mo*, is a tuple *(oid, v)*, in which *oid* is an element of set *ID*. Function *New(void)* can generate a new object identifier, which is different from other objects. And *v* is an n-tuple $(a_1{:}v_1, \ldots, a_n{:}v_n)$, here, object attribute $a_i(1 \le i \le n)$, which means the attribute type of this object, is an element of *A*. Function *Attributes(oid)* can get all attributes of the object whose identifier is *oid*. $v_i(1 \le i \le n,$ which is an element in set *V*, is the value of a_i. In the rest of this paper, we write $oid.a_i$ for the value of attribute a_i for the object with identifier *oid*.

3.2 Multimedia Description Unit

We represent a group of objects, which have certain relationships with each other, by a data structure named Multimedia Description Unit (MDU). The following is the formal definition of MDU.

Definition 2. A **Multimedia Description Unit** (MDU) is a triplet $u{:}<O,C,R>$. Here, *O* is a set of all objects that this MDU needs to describe. *C* is a set of all possible relationship types that maybe exist among objects. *R* is a subset of the mapping set $2^O \times 2^O \rightarrow C$, which represents all possible relationships between objects.

Following Allen's definition, *C* consists of at least the following 13 temporal relationship elements, *equal, starts, finishes, meets, overlaps, before, during,* $starts^{-1}$, $finishes^{-1}$, $meets^{-1}$, $overlaps^{-1}$, $before^{-1}$, $durings^{-1}$.

4 Temporal Semantic of Generalization

It is always necessary to answer the queries on generalization temporal semantics. For example, the query *to find an object set that appears at the same time with object A*, or *to find an object set that appears after object A.* These two queries do not need strict basic temporal relationships. It only needs to query through generalized temporal semantics relationship between objects. Figure 1 describes a hierarchy of one kind temporal generalization, in which the relationship *before* and *meets* are abstracted as *ahead,* which represents the predecessor relationship between objects, and so on.

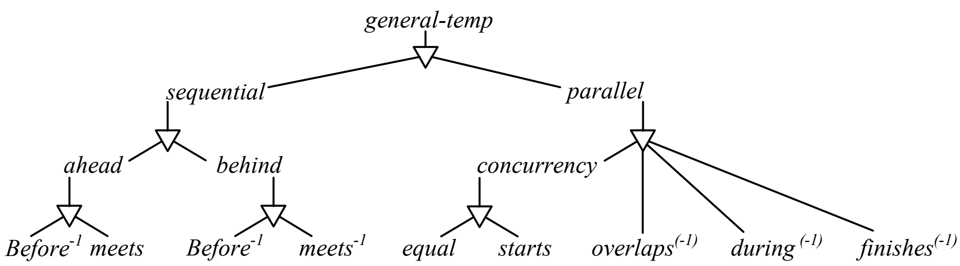

Fig. 1. An example of temporal generalization hierarchy ($c^{(-1)}$ means $c \cup c^{-1}$)

Allen's basic temporal relationships exist in the multimedia data that is described by MDU. For the queries with generalization temporal relationship, we have to get abstract temporal relationships between MDU objects according to the different generalization hierarchy.

> **Definition 3. Temporal relationship generalization** of a multimedia description unit *u* is the generalization abstraction of temporal relationship between objects in *u,* written as $Gen_T(u, hierarchy_i(H))$, which means a new multimedia description unit *u′* that is got from *u* through temporal generalization. Here, $hierarchy_i$ means a certain temporal generalization abstraction *i* in the form of a tree; *H* means a certain abstract node in this generalization abstraction. If all children of *H* are basic temporal relationship, we call *H* **direct generalization** of basic temporal relationship; if not, we call **indirect generalization**.

The temporal direct generalization is defined as:

$u' = Gen_T(u, hierarchy_i(H)) \Leftrightarrow u'.O = u.O, u'.C = u.C \cup H, u'.R = u.R \cup R'$, in which:

$R' = \{(O_i, O_j) \rightarrow H \mid \forall O_i, O_j \in u'.O, \exists c \in C, ((O_i, O_j) \rightarrow c) \in R \wedge H$ is the direct generalization abstraction of $c\}$

If abstract node *H* can be got through many times abstraction of basic temporal relationship *c,* such as the indirect generalization *sequential* of the basic temporal relationship $before^{(-1)}$ and $meets^{(-1)}$, temporal relationship generalization of MDU can be got through by a recursive algorithm. To a known generalization abstract structure, we can abstract the basic temporal relationship to every corresponding node in generalization structure; therefore it has been extending the description ability of MDU in the system. The following is a completed description algorithm for temporal relationship generalization semantic.

```
procedure gen_extend(MDU u, HIERARCHY h)
  gen_node(u, n) //the root note of generalization layer in form of tree is n
end procedure
function gen_node(MDU u, NODE n)
return MDU
  if (n is the directed generalization note of basic temporal relatioship)
  then return u=Gen_T(u, n)
  else begin
        find all generalization abstraction child note of n , signed as n_1, n_2, … ,n_k
        for i=1 to k do u_i= u_i ∪ gen_node(u, n_i)
        return u_i
      end
end function
```

The definition of temporal relationship generalization allows to do abstract temporal expression for temporal relationship between multimedia objects, which extends the expression capability of MDU in temporal relationship.

5 Temporal Aggregation Semantic

Aggregation semantics can aggregate some parts to a whole. For example, there is a video section, which is about the best scenes in a football game, and has described every team member as an object by MDU, including the temporal relationship between objects. However, if we want to answer the query like *to find all scenes including shooting team members and resist team member*s, we have to abstract some objects and their temporal relationship to a certain group, so we can make the objects like shooting team members and resist team members as a new shooting scene object. The essence of temporal aggregation semantics is to construct temporal relationship in higher layer granularity from temporal relationship in some lower layer granularity on temporal interval.

Definition 4. Temporal relationship aggregation in a multimedia description unit u is the aggregation abstraction of a set of object' sets $\{O^1,O^2,\ldots,O^m\}$ on u, (in which $\bigcup_{i=1}^{m} O^i \in u.O$), written as $Agg_T(u,\{O^1,O^2,\ldots,O^m\})$, which represents the new multimedia description unit u' gotten from temporal aggregation on u . If the set $\{O^1,O^2,\ldots,O^m\}$ only includes one set of objects, it is named as **basic aggregation**; otherwise, it is named as **complex aggregation**. To the basic aggregation, if $O^1=\{O_1,O_2,\ldots,O_n\}$, then we can define:

$$u' = Agg_T(u,\{O_1,O_2,\ldots,O_n\}) \Leftrightarrow u'.O = u.O \cup O'$$

Here, the object O' is a new object aggregateed from the set of objects $\{O_1,O_2,\ldots,O_n\}$, whose object identifier, which is different from other identifiers, is created by the system, and the set of attributes, which is shown as following, is gotten from objects in $\{O_1,O_2,\ldots,O_n\}$:

$$O'.ID = New(MO), Attibutes(O'.ID) = \bigcup_{i=1}^{n} Attibutes(O_i.ID)(O_i \in \{O_1,O_2,\ldots,O_n\})$$

Temporal interval attribute I in the new multimedia object O' can be gotten from granularity approximation operation. Let G_i be the granularity before aggregation; and G_j be the granularity after that. The formal calculation of is defined as following:

$$O'.I = \bigcup_{i=1}^{n} App_{G_i}^{G_j}(O_i.I)(O_i \in \{O_1,O_2,\ldots,O_n\})$$

New object will be created after aggregation semantic abstraction, and has extended the former temporal relationship set of multimedia description unit. Therefore, some operation is required to get the temporal relationship type set C and temporal relationship set R' of u'. The detailed operation is shown as following:

$$C' = \{aggregate, aggregate^{-1}\},$$

$$R' = \{(O_i, O') \rightarrow aggregate, (O', O_i) \rightarrow aggregate^{-1} \mid O_i \in \{O_1, O_2, \ldots, O_n\}$$

Then, we can get a new complete multimedia description unit u' as following:

$$u'.C = u.C \cup C', u'.R = u.R \cup R'$$

Applications should appoint the object set needed to be aggregateed for temporal aggregation abstraction, and this appointment is decided by the semantics of multimedia objects. For example, shoot scenes can be calculated by football shooting to the gate in a football match. Therefore, goal scenes should include the scene subset of football and gate.

6 Conclusion

this paper proposes a multimedia data model based on multimedia object description, and discusses the descriptive algorithm of generalization and aggregation, which are the two important temporal semantic abstractions. it is obviously that MDU model can perfectly describe generalization and aggregation, the two important temporal semantic abstractions, as well as support multimedia data independence, which means it can realize multimedia index and reform based on temporal features. Our future researches will be focused on the realizing of the above model, including temporal query processing, query optimizing and the design of query language of multimedia data.

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