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Extending the Conceptual Neighborhood Graph of the Relations for the Semantic Adaptation of Multimedia Documents

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***Abstract*—**The recent developments in computing and communication technology permit to users to access multimedia documents with variety of devices (PCs, PDAs, mobile phones…) having heterogeneous capabilities. This diversification of supports has trained the need to adapt multimedia documents according to their execution contexts. A semantic framework for multimedia document adaptation based on the conceptual neighborhood graphs was proposed. In this framework, adapting consists on finding another specification that satisfies the target constraints and which is as close as possible from the initial document. In this paper, we propose a new way of building the conceptual neighborhood graphs to best preserve the proximity between the adapted and the original documents and to deal with more elaborated relations models by integrating the relations relaxation graphs that permit to handle the delays and the distances defined within the relations.

***Keywords*—**Conceptual Neighborhood Graph, Relaxation Graphs, Relations with Delays, Semantic Adaptation of Multimedia Documents.

I. Introduction

IN [5], a semantic framework for multimedia document adaptation based on the qualitative specifications of multimedia documents and the conceptual neighborhood graphs (CNG) of the relations was proposed. In this framework, a multimedia document is considered as a set of potential executions corresponding to the author specification and to each target device corresponds a set of possible executions that complies with the target profile constraints. In this context, adapting requires to select an execution that satisfies the target device constraints and which is as close as possible from the initial document. However, the use of the CNG of the relations where all the weights of the arcs are set to 1, assumes that a relation can be replaced by any one of its neighbors whereas there might exist differences of proximity between them. Moreover, the relations of the used model (model of Allen [1]) do not consider the delays or the distances while the documents are generally produced using more elaborated models to insure a high expressiveness level which is a highly prized quality in the multimedia document authoring systems.

In section 2, we propose a new way of building the CNG of the relations to best preserve the proximity between the adapted and the original documents and to deal with more elaborated relations models. To validate our proposition, we present in section 3, the adaptation procedure and an example of adaptation illustrating our contribution. Section 4 concludes this paper and present our future works.

II. Extension of the Conceptual Neighborhood Graph

To best preserve the proximity between the adapted and the initial documents and to extend the approach to deal with relations models that define delays and distances, we will propose a new way of building of the CNG of the relations. In the reminder of this paper, to illustrate and validate our work, we will use the *Wahl* and *Rothermel* model of the temporal relations [6]. The same reasoning can be applied to spatial and hypermedia dimensions.

A. Weighting of the Conceptual Neighborhood Graph

In [5], the weights assigned to the arcs of the graph are set to one (01). To replace a relation that does not meet the profile constraints with the closest, we propose a new weighting of the arcs. For this, we start by identifying all the information elements characterizing a relation which will serve as criteria of proximity comparison between the relations.

1. Information elements of a relation

The analysis of a relation between two media A and B (Fig. 1) on a time axis showed that the positioning is done according to the values and the order (precedes (>), succeeds (<) or equal (=)) of their respective edges (beginning and ending instants of the media objects). Table I gives the 16 selected information elements that characterize a relation. For each relation, we attribute the value of one (01) when the information element is contained and zero (0) elsewhere. Table II gives the information elements of the relation of the *Wahl* and *Rothermel* model.

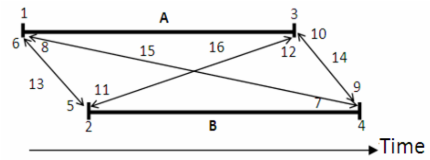

Fig. 1 Information of a relation

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TABLE I
INFORMATION CHARACTERIZING A RELATION

Information	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Signification	b(A)	b(B)	e(A)	e(B)	1>2	1<2	1>4	1<4
Information	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Signification	3>4	3<4	3>2	3<2	1=2	3=4	1=4	3=2

TABLE II
INFORMATION OF THE TEMPORAL RELATIONS

Symbol	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Before	0	1	1	0	0	1	0	1	0	1	0	1	0	0	0	0
Overlaps	1	1	1	1	0	1	0	1	0	1	1	0	0	0	0	0
Endin	0	1	1	1	0	1	0	1	0	1	1	0	0	0	0	0
Cobegin	1	1	0	0	0	1	0	1	0	1	1	0	0	0	0	0
Coend	0	0	1	1	0	1	0	1	0	1	1	0	0	0	0	0
Beforeendof^{-1}	0	1	1	0	0	1	0	1	0	1	1	0	0	0	0	0
Cross^{-1}	1	1	1	1	0	1	0	1	0	1	1	0	0	0	0	0
Delayed^{-1}	1	1	1	1	0	1	0	1	0	1	1	0	0	0	0	0
Startin^{-1}	1	1	1	0	0	1	0	1	0	1	1	0	0	0	0	0
While	1	1	1	1	1	0	0	1	0	1	1	0	0	0	0	0
Contains	1	1	1	1	0	1	0	1	1	0	1	0	0	0	0	0
Beforeendof	1	0	0	1	1	0	0	1	1	0	1	0	0	0	0	0
Cross	1	1	1	1	1	0	0	1	1	0	1	0	0	0	0	0
Delayed	1	1	1	1	1	0	0	1	1	0	1	0	0	0	0	0
Startin	1	1	0	1	1	0	0	1	1	0	1	0	0	0	0	0
Cobegin^{-1}	1	1	0	0	1	0	0	1	1	0	1	0	0	0	0	0
Endin^{-1}	1	0	1	1	1	0	0	1	1	0	1	0	0	0	0	0
Coend^{-1}	0	0	1	1	1	0	0	1	1	0	1	0	0	0	0	0
Overlaps^{-1}	1	1	1	1	1	0	0	1	1	0	1	0	0	0	0	0
Before^{-1}	1	0	0	1	1	0	1	0	1	0	1	0	0	0	0	0

2. Calculation of the similarity degree between relations

To calculate the similarity degree between a relation and its immediate neighbors, we use the Manhattan distance defined as follows: The Manhattan distance between a relation *r* and its neighbor *r'* is: d (r, r')= $\Sigma^{16}_{i=1} |v_i - u_i|$ where v_i and u_i are respectively the 16 information elements of *r* and *r'*. Table III gives the distances of each relation and its neighbors.

TABLE III
DISTANCES BETWEEN THE RELATIONS AND THEIR NEIGHBORS

	b	o	e	cb	ce	beo^{-1}	c^{-1}	d^{-1}	s^{-1}	w	cn	beo	c	d	s	cb^{-1}	e^{-1}	ce^{-1}	o^{-1}	b^{-1}
b	-	4	3	4	4	2	4	4	3	-	-	-	-	-	-	-	-	-	-	-
o	4	-	-	-	-	-	-	-	-	2	2	-	-	-	-	-	-	-	-	-
e	3	-	-	-	-	-	-	-	-	3	3	-	-	-	-	-	-	-	-	-
cb	4	-	-	-	-	-	-	-	-	4	4	-	-	-	-	-	-	-	-	-
ce	4	-	-	-	-	-	-	-	-	4	4	-	-	-	-	-	-	-	-	-
beo^{-1}	2	-	-	-	-	-	-	-	-	4	4	-	-	-	-	-	-	-	-	-
c^{-1}	4	-	-	-	-	-	-	-	-	2	2	-	-	-	-	-	-	-	-	-
d^{-1}	4	-	-	-	-	-	-	-	-	2	2	-	-	-	-	-	-	-	-	-
s^{-1}	3	-	-	-	-	-	-	-	-	3	3	-	-	-	-	-	-	-	-	-
w	-	2	3	4	4	4	2	2	3	-	-	4	2	2	3	4	3	4	2	-
cn	-	2	3	4	4	4	2	2	3	-	-	4	2	2	3	4	3	4	2	-
beo	-	-	-	-	-	-	-	-	-	4	4	-	-	-	-	-	-	-	-	2
c	-	-	-	-	-	-	-	-	-	2	2	-	-	-	-	-	-	-	-	4
d	-	-	-	-	-	-	-	-	-	2	2	-	-	-	-	-	-	-	-	4
s	-	-	-	-	-	-	-	-	-	3	3	-	-	-	-	-	-	-	-	3
cb^{-1}	-	-	-	-	-	-	-	-	-	4	4	-	-	-	-	-	-	-	-	4
e^{-1}	-	-	-	-	-	-	-	-	-	3	3	-	-	-	-	-	-	-	-	3
ce^{-1}	-	-	-	-	-	-	-	-	-	4	4	-	-	-	-	-	-	-	-	4
o^{-1}	-	-	-	-	-	-	-	-	-	2	2	-	-	-	-	-	-	-	-	4
b^{-1}	-	-	-	-	-	-	-	-	-	-	-	2	4	4	3	4	3	4	4	-

B. Relations Models with Delays

In the editing phase of a multimedia document, the author uses, generally, models that define delays, for their high expressiveness degree. Therefore, our approach should deal with this type of models. For this, we replace each node of the CNG of the relations by a graph called relaxation graph (RG). The RG is constituted by the different forms that can take a relation: considering the delays specification as a strong constraint in the relation, those different forms are obtained by relaxing this constraint to a weaker constraint. For instance, the relaxation of the relation *A before (5) B* would be the relation *A before (-) B* where the symbol "-" represent a relaxation stat of the relation and the value of the delay is to be determined by the constraints solver used for the consistency verification and the solution calculation (in our case, we use the Cassowary Solver [2]).

Generally, the RG of a relation is obtained by a progressive relaxation of the delays within this relation. Fig. 2 gives the RGs of the temporal relations with one, two or three delays (three is the maximum number of delays in Wahl and Rothermel Model).

Thus, the relaxation may lead to an adaptation solution without replacement of the relations that do not meet the target profiles and consequently, the adapted document may be closer to the initial document.

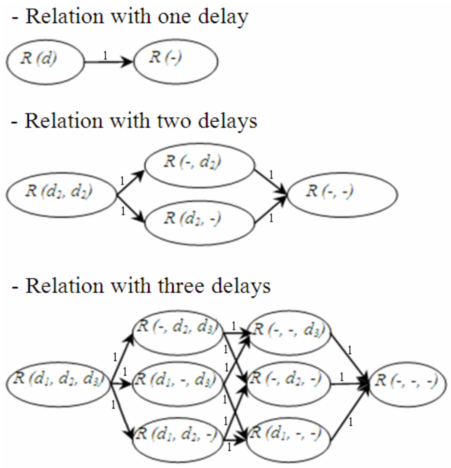

Fig. 2 Relaxation graphs of the relations

Since the relaxation order of the delays does not affect the proximity of a relation with its neighbors in the relaxation graph, we set the weights of all of the arcs of the RGs to one (01).

C. Conceptual Neighborhood Graph Construction and Traversal

To determine the neighbors of a relation, we start by elaborating the CNG of the *Wahl* and *Rothermel* relations as proposed in [4] then; we replace each node (relation) by its corresponding relaxation graph to take into consideration the delays.The graph traversal starts from the relation to be replaced. According the defined delays in that relation, we identify the corresponding node in the relaxation graph then, we traverse the graph starting from this node. Once the ending node of the relaxation graph (node where all the delays are relaxed) is achieved, we move to the following node in the CNG where all the delays are relaxed. Moving directly to the node where all the delays are relaxed, when changing the relation in the CNG is due to the fact that the definition given to a relation is not the same for another relation. Therefore, it's not possible to move from a relation without delays to another relation while keeping the initial defined delays. Fig. 3 gives the conceptual neighborhood graph of the relations of the Wahl and Rothermel model.

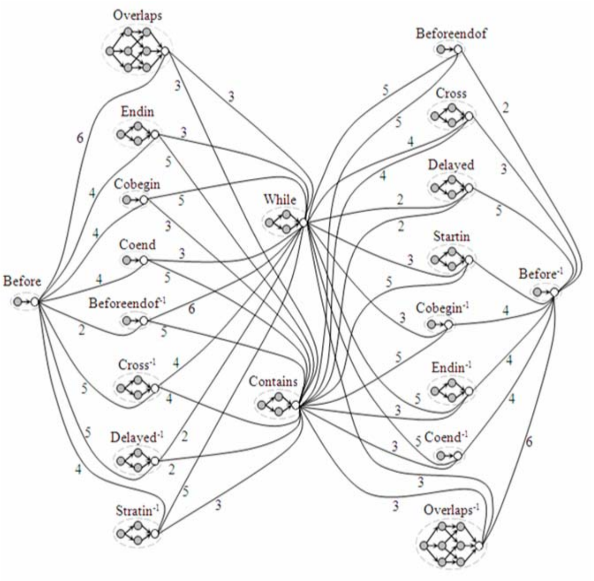

Fig. 3 The final conceptual neighborhood graph

III. Adaptation Procedure

The semantic adaptation of multimedia documents is achieved by modifying the specification of the document. This involves finding another set of values to the delays of the relations or otherwise a set of relations satisfying the adaptation constraints of the target profile. This set of relations is obtained by combining the candidate relations to the replacement of each relation of the initial document. The adapted document will correspond to the coherent solution with the smallest conceptual distance [5] defined as follows: $dc(sol)_k = \sum^{n}_{i=1} dc(r_i, r_j)$ with n is the document relations number, r_j is a candidate relation to the replacement of the relation r_i and *dc(ri,rj)* is the conceptual distance r_i between and r_j. For the temporal relations, *dc(ri,rj)* is calculated by traversing the CNG and searching for the shortest path between the two relations.

For instance, *dc(Before(-), while (-, -)) = dc (before (-), endin(-)) + dc (endin(-), while(-, -))* = 4 + 3 = 7.

A. Adaptation Algorithm

```
Input : MI1j:  //Matrix of the document relations
// replacement relations search
For i = 0 to n-1 do     // n number of objects
   for j = 0 to n-1 do
        For k=1 to NR do   // NR : number of the relations of the model
           if respecteProfil (Rm [k]) then  //Rm set of the model relations
              MS [i, j] ← MS [i, j] ∪ {Rm [k]};
           End if
        End for
   End for
End for

// Elaboration of the possible combinations
//output : combinations list  Cp
Cp = ElaborateCombinationsMatrix(MSij);

// Sort combinations according to the conceptual distance
For i=0 to nCombinations -1 do
   d[i] ← 0;                          // Matrix of the conceptual distances
   For j=0 to n-1 do
      d[i] = d[i] + Djikstra(C[i,j], MR[i,j]);
   Endfor
Endfor
QuickSortCombinations(C[i], d[i]);

// Consistency Verification
found ← false ;
For i = 0 to nCombinations -1 do
   if Consistency (C[i]) Then
Solution ← (C[i]);
found ← true ; Break ;
   End if
End for
If found = false Then Write ('no adaptation ');
```

The algorithm takes as input the matrix MI_{ij}: matrix of the complete relations graph of the initial specification (figure 5.b for example). Once the substitution matrix MS_{ij}, which gives for each relation of the matrix M_{ij} the relations candidates for its substitution from those that respects the target profile constraints among the relations of the model, is identified, we determine by combinations, all the possible solutions C_i from the matrix MS_{ij}. Next, we perform an ascending sort of all solutions of C_i with the classical sorting algorithm "*quick sort*" using the conceptual distances calculated by using the *Dijkstra's* shortest path *algorithm*. This will ensure that the solutions are sorted from the closest specification to the farthest from the original. Finally, we call the constraints solver (cassowary [2]) for the consistency verification and the calculation of the solution for each specification in the order defined by the sort. The first verification that gives a consistency stops the process of solutions consistency verification.

B. Example of Adaptation

Let us consider the initial multimedia document of Fig. 4 and the following profile:

- Media objects should not start at the same time.
- Streaming objects cannot be played simultaneously.

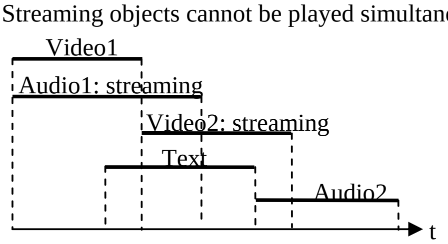

Fig. 4 (a) Temporal representation

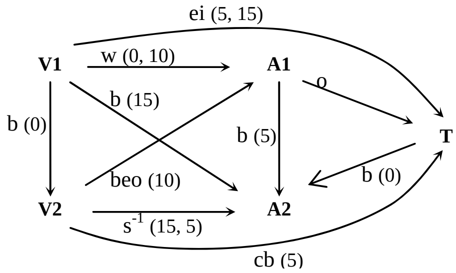

Fig. 4 (b) Relations graph

The relations *video1 while (0, 10) audio2* and *video2 beforeendof (-) audio1* do not meet the target profile constraints. For that reason, the document must be adapted. After the execution of the adaptation algorithm, we obtain the solution given in Fig. 5. Table IV summarizes all the performed modifications of the relations and gives an idea on the proximity of the solution and the initial document.

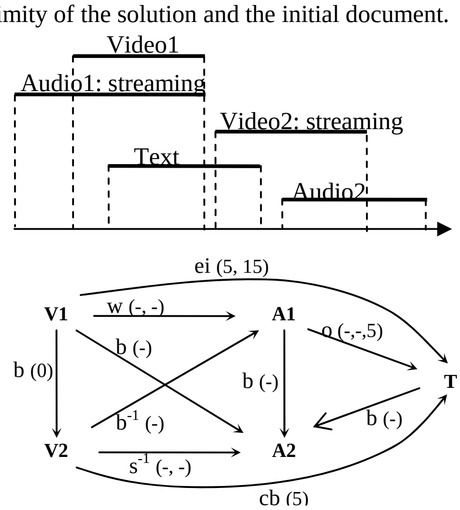

Fig. 5 The adapted document

TABLE IV
THE MODIFICATION APPLIED TO THE RELATIONS

Initial specification	Adaptation solution	Action
V1 w (0, 10) A1	V1 w (-, -) A1	Relaxation
V1 b (0) V2	V1 b (0) V2	No change
V1 e (5, 15) T	V1 e (5, 15) T	No change
V1 b (15) A2	V1 b (-) A2	Relaxation
V2 beo (10) A1	V2 b-1 (-) A1	Replacement
A1 o (15, 15, 5) T	A1 o (-, -, 5) T	Relaxation
A1 b (5) A2	A1 b (-) A2	Relaxation
V2 cb (5) T	V2 cb (5) T	No change
V2 s-1 (15, 5) A2	V2 s-1 (-, -) A2	Relaxation
T b (0) A2	T b (-) A2	Relaxation

Among the initial document relations, only one relation was replaced. The others were maintained (03 relations kept and 06 relations relaxed).

IV. CONCLUSION

In this paper we proposed a new construction of the conceptual neighborhood graph of the temporal relations. Thus, the adapted document is as close as possible to the initial document. Moreover, this approach takes into consideration the treatment of the relations delays and can be applied for the spatial and the hypermedia dimensions. Moreover, as the objective is primarily to best preserve the message intended by the author of the original document (Otherwise what is the benefit of such an adaptation?), it seems quite rightful to ask the following question: Is it appropriate to deliver the adapted document even though the message of the original document may be completely changed? Otherwise what are the parameters should be taken into account?

The first direction of our future work would be to determine the similitude measure between the adapted document and the original one by using some extra information (annotations) like weights assigned to relations based on their importance in the specification to determine relations to be modified or to removed if it's necessary and also using forms to collect the user preferences.

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