Spatial adaptation of multimedia documents

Azze-Eddine Maredj
Research Center on Scientific and technical information
05, Rue des trois frères Aisiou Ben-Aknoun
Algeria.
amaredj@mail.cerist.dz

Nourredine Tonkin
Research Center on Scientific and technical information
05, Rue des trois frères Aisiou Ben-Aknoun
Algeria.
ntonkin@mail.cerist.dz

Abstract—**With the proliferation of heterogeneous devices (desktop computers, personal digital assistants, phones), multimedia documents must be played under various constraints (small screens, low bandwidth). Taking these constraints into account with current document models is impossible. Hence, generic source documents must be adapted or transformed into documents compatible with the target contexts. The adaptation consists in modifying this specification of the document in a minimal way to lead it to satisfy the target profile. The profile defines constraints that must be satisfied by the document to be played. At this level, the transgressive adaptation becomes necessary when no specification model exists to satisfy this profile. We focus on the spatial dimension of a multimedia document and we provide an approach to the spatial adaptation of multimedia documents that permit to best preserve the initial document semantic by weighting the conceptual neighborhood graph and the integration of the distances relaxation.**

Index Terms— **multimedia document, spatial adaptation, conceptual neighborhood graph, distance relaxation**

I. INTRODUCTION

A Multimedia document should be able to be played on different platforms (mobile phones, PDAs, laptops, PCs…) and must be presented according to the user preferences. The challenge is to execute and transmit to users media objects with a high quality in a consistent presentation that reproduces as closely as possible the semantics of the original document.

To deal with the diversification of target contexts and user preferences, multimedia document must to be adapted before being played, i.e., from the profile (hardware and software constraints and user preferences) and the source document, the adaptation must transform the document to be compatible with the target profiles.

A lot of works has been done in this way and showed that there are two types of adaptation. The first type is to specify directly the different organizations of the document for each target platform. In this case, the task becomes complex since it requires an extra work to the author when he should specify the conditions of execution of its document on each target context. It can also be incomplete since the author must foresee all existing targets. The second type of adaptation is based on the dynamic adaptation of the document performed by a program transforming the document. In this type, two kinds of adaptation are possible: a local adaptation that considers the media individually but does not most often, preserve the document semantics and global adaptation related to the document composition (taking into account temporal, spatial and hypermedia dimensions) and which preserves the semantics of the document [1].

This paper focuses on the latter type of the adaptation and concerns only the spatial aspect. It is devoted to the transgressive adaptation of the spatial relations where the document is represented by an abstract structure expressing all relations between media objects. In this context, adapt a multimedia document consists in transforming the abstract structure in a manner that it meets the requirements for the target profile.

In [1], it was shown that a spatial relation is represented by the combination of the Allen relations [2] on the horizontal and vertical axes and the spatial adaptation follows the same principle as the one defined for the temporal adaptation [3]. This principle says that if no model of the original specification of the multimedia document satisfies the adaptation constraints (context constraints) then transgressive adaptation is applied. In this approach, the transgressive adaptation consists in transforming the relations between multimedia objects while ensuring two main properties: (i) the adaptation constraints are satisfied and (ii) the adapted document is as close as possible to the initial document. This consists in finding another set of models (solutions), close to the initial, which satisfies these constraints. The proposed solution is to replace each relation that does not meet the profile by another semantically close. To find the closest relations, the conceptual neighborhood graph of spatial relations proposed in [4] is used.

In this approach, the specification is done using models (temporal and spatial) where delays and distances between media objects are not considered, when actually, the produced documents (which are subjects of adaptation) are often, for expressiveness purpose, composed using very complexes models.

In our previous works [5], we showed the interest of the weighted conceptual neighborhood graph usage when seeking for the closest substitution relations and the saving of time that results.

In this work, we will extend this approach to spatial models where distances between media objects are defined.

In the second section of this article, we present the context of our work. The third section presents our approach to the spatial adaptation. In the fourth section we present the adaptation procedure and the last section concludes this paper.

II. CONTEXT

A multimedia document specification comprises temporal relations defining inter media objects synchronization and spatial relations that express the spatial representation of these media objects. The different users of multimedia documents impose different presentation constraints on the specification like display capabilities (screen size and resolution). The user's device may do not have the necessary capabilities to support the spatial constraints of the document.

For example, let us consider a multimedia document with the following spatial relation: *image B Above image A* and the resolution of the two images is 200 x 300. If the terminal resolution is superior or equal to 400 x 600 than, the user will not have any issue when displaying this document but, if its resolution is inferior to 400 x 600, we can have the following solutions [6]: (i) delete one of the two images or (ii) resize image A or image B or (iii) change the spatial relation *Above* by another relation.

The deletion of one of the two images may alter or produce an incomprehensible document. Resizing one of the objects will not affect the relation between them but may lead to a wrong interpretation or make the image indistinguishable in the case of an X-ray radio for example. The spatial relation modification does not cause information waste as in the image deletion and does not make indistinguishable the images. It only changes the places of those images.

Here, we focus on the relations transformation while trying to preserve the document semantic as well as possible.

Before we present the spatial adaptation of multimedia documents, we start by giving the chosen spatial model for spatial relations specification.

A. Spatial relations model

To describe the spatial presentation of a multimedia document, we use the directional spatial representation [7] that permits to define the orientation in space between media objects.

In this representation, a media object is considered as two intervals corresponding to its projection on the horizontal and vertical axes. The set of the directional relations is obtained by combining the intervals of the two media objects on the two axes by using the Wahl and Rothermel relations model [8] presented in figure 1, on each axis. There are 20 relations between two intervals on each axis, which give us $20^2 = 400$ possible spatial relations between two media objects. Thus, a spatial relation is represented by two temporal relations [1] : one on the horizontal axis and one on the vertical axis. For example, the spatial relation *left_top* can be represented by its two components: *before* (on the horizontal axis) and *before* (on the vertical axis).

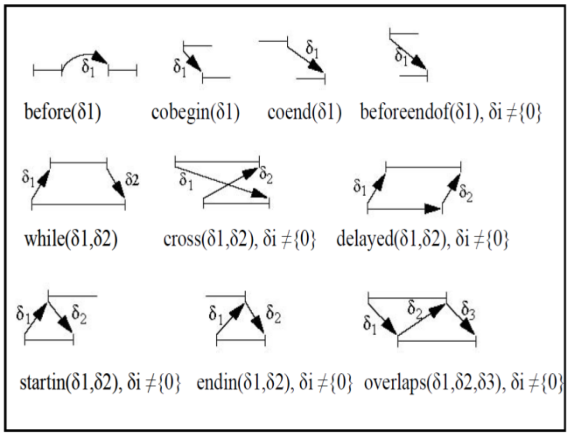


Fig1. The spatial relations model of Wahl and Rothermel

III. SPATIAL ADAPTATION

In the multimedia document spatial adaptation, we follow the same procedure as the one we presented for the temporal adaptation in [5].

A. Conceptual neighborhood graph of the spatial relations

The representation of the spatial relations by two components (temporal relations) permits us to use the conceptual neighborhood graph of the temporal relations [4] to elaborate the spatial relations conceptual neighborhood graph. Indeed, for each component of the spatial relations (vertical and horizontal components), we use the temporal relations conceptual neighbourhood graph. The composition of the two graphs gives us the conceptual neighborhood graph of the spatial relations. It's the square product of the conceptual neighborhood graph of temporal relations.

Conceptual neighborhood graph

Two relations between two media objects are *conceptual neighbors* if they can be directly transformed into one another by continuous deformation (shortening or lengthening) of the duration of the media objects without going through an intermediate relation.

For example, in figure 2, the relations *before* and *Overlaps* are conceptual neighbors since a temporal extension of the media object *A* may cause a direct transition from the relation *before* to the relation *Overlaps:*

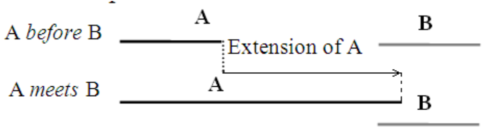


Fig2. Example of neighboring relations

And in figure3, the relations *before* and *Contains* are not conceptual neighbors, since a transition between those relations must go through one of the relations *Overlaps, Endin, Cobegin, Coend, Beforeendof^{1}, Cross^{-1}, Delayed^{-1} or Startin^{-1}*.

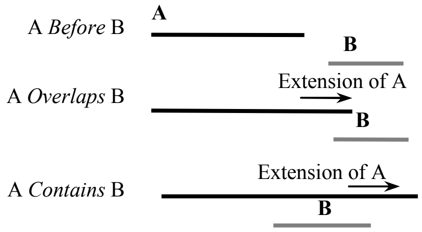


Fig3. Example of non-neighboring relations.

The Conceptual neighborhood graph, presented in figure4, is defined as a graph where the nodes correspond to the relations of Wahl and Rothermel model and each arc between two nodes (relations) ***r*** and ***r'*** corresponds to the satisfaction of the propriety of the conceptual neighborhood, i.e., ***r*** and ***r'*** are conceptual neighbors.

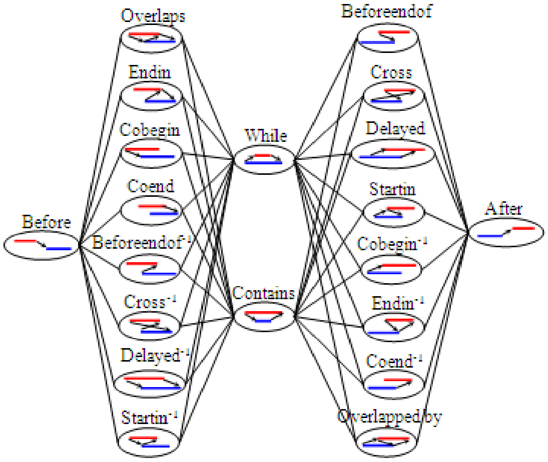


Fig.4. Conceptual neighborhood graph of the Wahl and Rothermel relations

Weighting of the conceptual neighborhood graph

In the conceptual neighborhood graph as presented in [3], the weights of the arcs are set to 1. This assumes that a relation can be indifferently replaced by any of its neighbors with the same smallest conceptual distance whereas there may be a substantial difference between the candidates Relations. It would be interesting to differentiate the proximity degree between these relations. The distinction in the proximity of neighboring relations is done by assigning different weights to the arcs of a graph.

To assign different weights to the arcs of a conceptual neighborhood graph, the idea is to identify all information that characterizes a temporal relation so that they serve as a basis for comparing and differentiate the similarity between the relations.

Information of a relation

The analysis of a relation between two media A and B (Figure 5) on a time axis showed that the positioning is done according to the order that exists between their respective edges (occurrence order of the beginning and ending instants of the media objects). Therefore, to characterize a temporal relation, we selected the following information: the values of the beginnings and the endings of the media objects and the orders (precedes (>) or succeeds (<)) between their edges.

Table1 gives a recapitulation of the selected pieces of information.

Then, we have for each relation, determined the information that it contains among the selected ones and the result is given in Table 2 below.

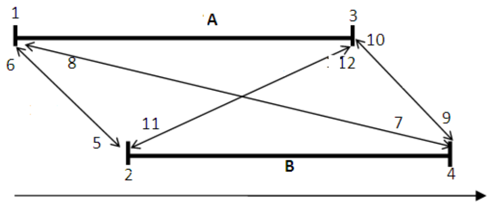


Fig.5. Information of a relation

information	1	2	3	4	5	6
Signification	d(A)	d(B)	f(A)	f(B)	1 > 2	1 < 2
information	7	8	9	1 0	11	12
Signification	1 > 4	1 < 4	3 > 4	3 < 4	3 > 2	3 < 2

TABLE I
INFORMATION THAT CHARACTERIZES A TEMPORAL RELATION.

	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

TABLE II.
INFORMATION CONTAINED IN THE WAHL AND ROTHERMEL RELATIONS

Calculation of the similarity degree between a relation and its immediate neighbors

To calculate the similarity degree between a relation and its neighbors, we use the *Manhattan distance* defined as follows: Let us consider the two vectors V ($v_1, v_2 \dots v_n$) and U ($u_1, u_2 \dots u_n$). The Manhattan distance between V and U is:

$$d_{(V-U)} = \Sigma^{n}_{i=1} |v_i - u_i|$$

In our work, we consider the information pieces of each relation as a vector where the value of each information piece is set to 1whether this information is included in the relation or zero (0) otherwise.

Using the Manhattan distance, we established the distances between each relation and its immediate neighbors that permit us to weight the conceptual neighborhood graph as shown in figure6.

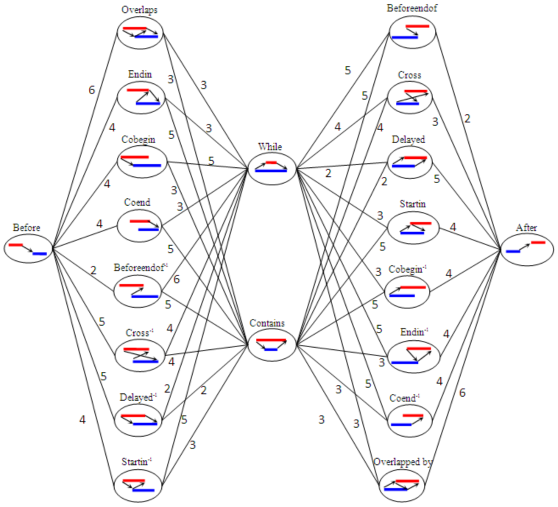


Fig.6. Weighted Conceptual neighborhood graph of Wahl and Rothermel relations.

The conceptual distance of a spatial relation

The conceptual distance between two relations ***r*** and ***r'*** is the length of the shortest path between those relation in the conceptual neighborhood graph.

The conceptual distance of a spatial relation is defined as the sum of the conceptual distances of its two components (temporal relations on the two axes). For example, let's consider the two spatial relations r_1=<Before, Overlaps> and r_2=<Endin, While>. The conceptual distance between r_1 and r_2 is $d_x (r_1, r_2) + d_y (r_1, r_2)$ i.e, d (Before, Endin) + d (Overlaps, While).

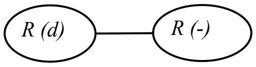
A. Distance relaxation

According to the consideration of a spatial relation as two temporal relations, its distances are then taken as delays in the two temporal relations. In this case, before seeking for substitution relation, we start by trying to relax these delays in order to keep the relations and give us the opportunity to best preserve the semantic of the initial document.

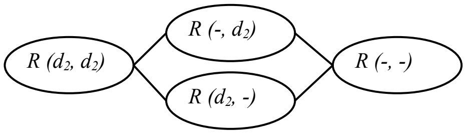
For example, the relation A Before (d) B can be transformed to the relation A Before (-) B where the symbol "-" means that the distance is not specified.

We present below, the delays relaxation of the temporal relations of the Wahl and Rothermel Model. For this, we use a graph structure based on the number of delays defined for a relation as shown in figure7.

- Relation with one delay:



- Relation with two delays:



- Relation with tree delays:

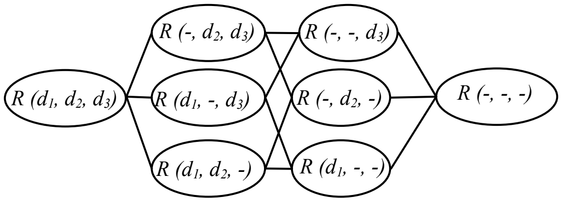


Figure7: delays relaxation graphs

To illustrate this principle, consider the example of the figure8 where the specified relation is
Image <*Overlaps (200,50,250>,*
Contains (10, 90)> Text
And the target screen size is 480 x 360.

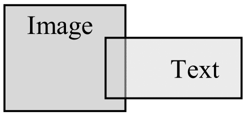


Fig.8. Example of a spatial specification

The two objects cannot be displayed because the width of the area they occupy (500 px) is larger than the screen width (480 px). The relaxation distances of this relation can lead to an adaptation solution without changing the relation and this solution can be: Image <*Overlaps (180, 70, 230>, Contains (10, 90)> Text* (see figure9).

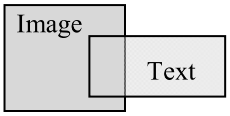


Fig.9. An adaptation solution with distance relaxation

If we proceeded directly by replacing the relation as was proposed in [1] then, the relation *Overlaps* will be directly replaced by the relation *While* and we will get the result of the figure10.

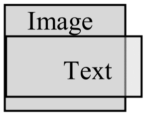


Fig.10. An adaptation solution without distance relaxation

IV. ADAPTATION PROCEDURE

The semantic adaptation of a multimedia document is achieved by modifying the specification of the document. This involves finding another set of values to the distances of the relation or otherwise a set of relations satisfying the adaptation constraints of the target platform with the smallest distance of the initial specification.

The distances relaxation or the relations replacement principles is done by traversing the graphs in both directions. This is done by searching the shortest path between the relation to replace and the other relations of the graph. The relation with the shortest path to the original is considered as candidate to replace it only if it does not lead to an inconsistency (for this we recommend the use of the Cassowary resolver [9]).

The adaptation procedure is done by following two phases: Distances relaxation and transgressive adaptation.

a. Distances relaxation

For each relation that does not respect the profile constraints, we determine the different possible relaxations of these distances then, we elaborate different combinations of the document relations based on these relaxations. After that, we calculate for each combination (new specification) the conceptual distance based on relaxation graphs defined in (§3.2). Then, we do an ascending sort of the combinations according to this conceptual distance. Finally, we check the consistency of these specifications and the compatibility with the target profile starting by the one with the smallest conceptual distance according to the performed sort. At the first meeting of a specification consistency and compatibility with the context, the verification process stops.

b. Transgressive adaptation

If at the end of the distances relaxation phase, no solution is found, we perform the transgressive adaptation: we elaborate the combinations of the candidate relations to replace the forbidden ones with the other relations of the document. We sort these combinations according to the conceptual distance and we check the consistency and compatibility with the constraints of profile. The first meeting with a consistent combination stops the verification and adaptation process.

V. CONCLUSION

In this paper, we proposed an approach to the transgressive adaptation of spatial relations of a multimedia document that takes into account the distances defined in the relations.

The weighting of the conceptual neighborhood graph and the proposed treatment of the relations distances by the relaxation principle permitted us to replace a relation with its closest semantically and thus to better preserve the similarity between the adapted document and the original.

Moreover, taking into account only the relation that transgress the profile, contrary to what was proposed in [1], allowed us to significantly reduce the response time for adaptation.

However, it seems important to ask this question: Is it appropriate to deliver the adapted document even if the message of the original document may be completely changed? If not, what are the parameters should be taken into account?

The first axe of 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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