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Novel Indexing Method of Relations Between Salient Objects

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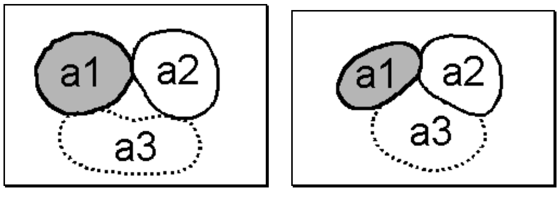
INTRODUCTION

During the last decade, a lot of work has been done in information technology in order to integrate image retrieval in the standard data processing environments (Rui, Huang & Chang, 1999; William & Grosky, 1997; Yoshitaka & Ichikawa, 1999).Relations between image objects are very frequently used to index the image-document (Peuquet, 1986). In medicine, for instance, the spatial data in surgical or radiation therapy of brain tumors are decisive because the location of a tumor has profound implications on a therapeutic decision (Chbeir, Amghar, & Flory, 2001). Hence, it is crucial to provide a precise and powerful system to express spatial relations. In the literature, three major types of spatial relations are proposed: metric (Peuquet, 1986), directional (El-kwae & Kabuka, 1999) and topological relations (Egenhofer, 1997; Egenhofer, Frank & Jackson, 1989).

In spite of all the proposed work to represent complex visual situations, several shortcomings exist in the methods of spatial relation computations. For instance, Figure 1 shows two different spatial situations of three salient objects that are described by the same spatial relations in both cases: topological relations: a1 Touch a2, a1 Touch a3, a2 Touch a3; and directional relations: a1 Above a3, a2 Above a3, a1 Left a2.

The existing systems do not have the required expressive power to represent these situations. Thus, in this article, we address this issue and propose a snapshot of our novel method that can easily compute several types of relations between salient objects with better expressions. The rest of this article is organized as follows. In the second section, we present related work in this domain. In the third section, we briefly present our method and discuss how it gives better results using spatial features. finally, conclusions and future directions are given in the fourth section.

Figure 1. Two different spatial situations



BACKGROUND

The problem of image retrieval is strongly related to image representation. The two different approaches used for the representation of images are: the metadata-based and the content-based approaches. Made with human assistance, the metadata-based representation uses alpha-numeric attributes to describe the context and/or the content of an image. The other approach for representation of images is using its low-level contents such as its color, texture, and shape (Remco & Mirela, 2000). The representations using low-level features are derived through feature extraction algorithms.

In both approaches, relations between either salient objects, shapes, points of interests, and so forth have been widely used in image indexing such as R-trees (Beckmann, 1990; Guttman, 1984), 2D-Strings (Chang & Jungert, 1991, 1997; Chang, Shi & Yan, 1987), and so forth. Temporal and spatial relations are the most used relations in image indexing.

To calculate temporal relations, two paradigms are proposed in the literature:

- The first paradigm consists of representing the time as a set of *instants:* $t_1,..t_i,..t_n$. Traditionally, only three temporal relations are possible between two objects: *before*, its symmetric relation *after*, and *equal*.
- The second paradigm considers the time as a set of intervals $[t_i, t_j]$. Allen relations (Allen, 1983) are often used to represent temporal relations between intervals. Allen proposes 13 temporal relations (Figure 2) in which six are symmetrical.

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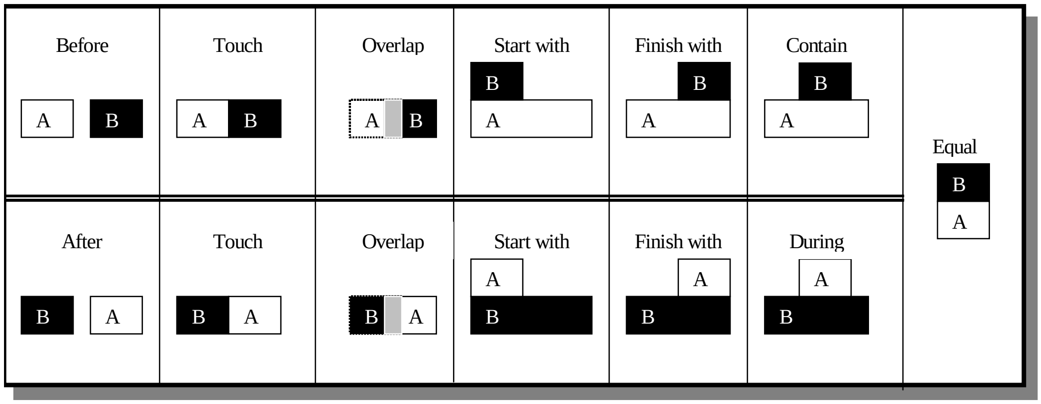
Figure 2. Allen relations



On the other hand, three major types of spatial relations are generally proposed in image representation (Egenhofer, Frank & Jackson, 1989):

- Metric relations: measure the distance between salient objects. For instance, the metric relation "far" between two objects A and B indicates that each pair of points A_i and B_j has a distance greater than a certain value δ.
- Directional relations: describe the order between two salient objects according to a direction, or the localisation of salient object inside images. In the literature, 14 directional relations are considered:
    - Strict: north, south, east, and west.
    - Mixture: north-east, north-west, south-east, and south-west.
    - Positional: left, right, up, down, front and behind.

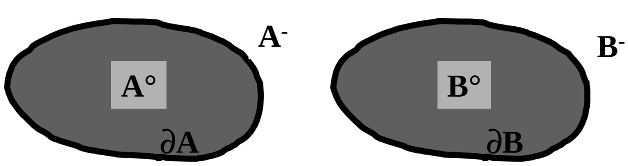
    Directional relations are *rotation variant* and there is a need to have referential base. Furthermore, directional relations do not exist in certain configurations.
- Topological relations: describe the intersection and the incidence between objects. Egenhofer (Egenhofer, 1997) has identified six basic relations: *Disjoint, Meet, Overlap, Cover, Contain, and Equal.* Topological relations present several characteristics that are *exclusive* to two objects (i.e., there is one and only one topological relation between two objects). Furthermore, topological relations have *absolute* value because of their constant existence between objects. Another interesting characteristic of topological relations is that they are transformation, translation, scaling, and zooming *invariant*.

PROPOSITION

The 9-Intersection model proposed by Egenhofer (Egenhofer, 1997; Egenhofer, Frank & Jackson, 1989) represents each shape "A" as a combination of three parts: *interior* **A°**, *boundary* ∂**A** and *exterior* **A**$^-$. The topological relations between two shapes are obtained by applying an intersection matrix between these parts (Figure 3). Each intersection is characterised by an empty (∅) or non-empty (¬∅) value.

Our proposal represents an extension of this 9-Intersection model. It provides a general method for computing not only topological relations but also other types of relations such as temporal, spatial, and so forth. The idea shows that the relations are identified in function of features of shape, time, and so forth. The shape feature gives spatial relations; the time feature gives temporal relations, and so on. To identify a relation between two salient objects, we propose the use of an intersection matrix between sets of features. Let us first consider a feature F. We define its intersection sets as follows:

Figure 3. The 9-Intersection model: The topological relation between two shapes is based on the comparison of the three parts of each one.



$$R(\mathbf{A},\mathbf{B}) = \begin{pmatrix} \mathbf{A}^\circ \cap \mathbf{B}^\circ & \mathbf{A}^\circ \cap \partial\mathbf{B} & \mathbf{A}^\circ \cap \mathbf{B}^- \\ \partial\mathbf{A} \cap \mathbf{B}^\circ & \partial\mathbf{A} \cap \partial\mathbf{B} & \partial\mathbf{A} \cap \mathbf{B}^- \\ \mathbf{A}^- \cap \mathbf{B}^\circ & \mathbf{A}^- \cap \partial\mathbf{B} & \mathbf{A}^- \cap \mathbf{B}^- \end{pmatrix}$$

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