A User Model for Spatial Relations

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Abstract. This paper introduces a user model to describe in a systematic way the spatial relations among objects in the space surrounding the user with the respect to the application context. Our study is addressed to provide the right binding between those relations and operators provided by geometric models.

1 INTRODUCTION

A user model is needed because the same word can have different meanings in different domains or situations: for example the spatial relation "left" could refer to something that is on the left of the user/point of view or on the left side of a reference object. This shows that there are different "specializations" of the general relation "left" and these need to be distinguished within a user model. Spatial linguistic expressions depend to a high degree on the immediate spatial surroundings, or a mental model (Tenbrink, 2007). This paper focuses on developing a user model describing the context and all possible spatial relations, based on the frame of reference theory (Retz-Schmidt, 1988). The model includes the possible correspondences between spatial relations at user level and underlying spatial operators.

2 THE USER MODEL

As a case study, we refer to a tourist guide with a satellite navigation system, which uses the user position, obtained from a GPS receiver, to provide information regarding points of interest in the user neighborhood. We envision a system with enhanced querying capabilities, such as assessing spatial relations among geographic objects, like in the queries: "What are those buildings ahead on the right?" or "How far is the next service area on this street?" In these queries, relations like "ahead", "right" and "far" can be mapped to underlying spatial operators.

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Spatial operators are divided into three main categories (Clementini and Di Felice, 2000):

1. topological: e.g., the museums *inside* Rome;
2. metric: e.g., L'Aquila is *east* of Rome, Rome is not *far* from L'Aquila.
3. projective: e.g., the restaurants *between* me and my hotel, the shops on the *right* of the road

To answer spatial queries we need to associate an unambiguous geometric description to user spatial relations: frequently a frame of reference is required, which is often implicit in the user context but needs to be explicitly identified. Frames of reference are a key concept in spatial reasoning (Gapp, 1994): they provide the basis for several types of spatial relations, and describe the space around the user.

Three basic types of frames of reference are distinguished in the literature (Retz-Schmidt, 1988):

- intrinsic frames of reference are established on an anchor object that determines the origin of the coordinate system as well as its orientation;
- extrinsic frames of reference may also inherit their origin from an anchor object; however, their orientation is determined by external factors such as the direction of motion or by a conventional object used as landmark.
- deictic frames of reference involve three objects: a primary object that is in a particular relation with the respect to the reference object and the point of view. The orientation is imposed on the reference object as seen by the point of view.

According to (Majid, et al., 2004), the same types of frames of reference are called intrinsic, absolute, and relative, respectively. Another way to characterize frames of reference is given by (Gallister, 2002) leading to two categories: egocentric (subject centered), which corresponds to deictic, and allocentric (other centered), which can correspond either to intrinsic or extrinsic, depending on whether the coordinates are centered inside or outside the reference object.

Let us consider the following queries:

1. What is the name of the street in front of the university?
2. What is the building ahead towards north?
3. What is the building to the left of the city hall?

If we analyze the queries above we can see that each of them must be interpreted under a different frame of reference: in the first one the frame of reference is intrinsic due to the fact that it is determined by the prominent front of the university building which is an intrinsic property of the reference object. In the second one, the underlying frame of reference is extrinsic since the conventional "north" direction is used as landmark. The frame of reference used in the third query is deictic: the reference object is the city hall and the spatial relation of the unknown building is expressed with respect to the point of view of the user.

All these examples can be seen as different interpretations of underlying projective properties of spatial objects: our aim is to compute them by means of the geometric model proposed in (Clementini and Billen, 2006), identifying mapping rules between the ternary projective relations and user relations. According to the model we need to identify two reference objects to make the partition of the plane. To answer queries of the first type, we can use the intrinsic front and back of university as reference objects, distinguishing in this way five different relations (fig.1). In the second type queries the user plays the role of the first primary object and the landmark (the north) plays the role of the second one: in this case four relations are defined (fig. 2). When the user query belongs to the third type, a deictic frame of reference is involved: the user becomes the first reference object corresponding to the point of view; the second reference object is the reference object chosen by the user; also in this case four relations are defined (fig.3).

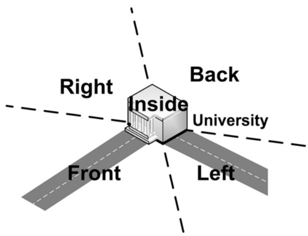

Figure 1: Relations for an intrinsic frame of reference

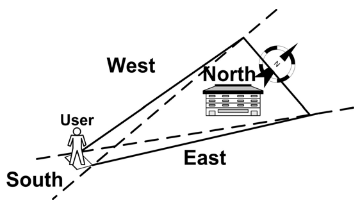

Figure 2: Relations for an extrinsic frame of reference

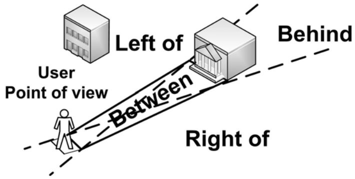

Figure 3: Relations for a deictic frame of reference

3 CONCLUSIONS

In this paper, we outlined our research activity to develop a user model for spatial relations. As a case study, we considered a tourist guide with capabilities to express queries by using typical concepts of the application and user domain. The model needs to be mapped at geometric level in order to perform computations with spatial objects. Our user model will provide the user with a set of all possible spatial relations on the basis of the context, in this way the user will be able to formulate queries with spatial operators that will be processed server side at a geometric level.

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