RIM: a ray intersection model for the analysis of the between relationship of 2D spatial objects

Abstract: The term between is frequently used to describe spatial arrangements where one core object is bounded by two or more peripheral objects. However, this ternary spatial relation is not expressible by existing qualitative spatial reasoning models. We propose a novel model for expressing nuanced spatial relationships between three spatial objects, called the Ray Intersection Model (RIM). RIM evaluates rays cast between two peripheral spatial objects (e.g. A and B in Figure 1), and their topological relations with the core object (e.g. O in Figure 1) to determine its relative position with respect to the peripheral objects. RIM has been computationally implemented and we demonstrate how RIM can be applied to analyse the arrangements of buildings at a university campus.

Ray set $R = \{r_1, r_2, ..., r_n\}$ is an infinite set of straight lines that connect peripheral objects A and B, but share exactly one point with each A and B.

Extreme rays ($r_j$) are distinct type of rays that are the first and last intersected by the medial axis between A and B (i.e. a point set in which all the points are equidistant from A and B). These rays are important because they enable RIM to distinguish if O is extending outside of the area between A and B or not.

RIM utilises the 9-intersection point-set intersection model (9IM) to describe the topological relationships between all the rays and the core object O. Although there can be an infinite number of rays $r_j \in R$, there will be a finite number of distinct topological relationships modelled with the 9IM (e.g. grey matrices in Figure 2), between individual rays and O. For example, in Figure 2 both extreme rays will form the same 9IM with O (‘disjoint’), while any other ray between A and B will either be disjoint from, touch (e.g. $r_3$), or cross (e.g. $r_3$) O.

RIM matrix is then formed by combining all the distinct 9IM relationships between rays R and O. It shows the intersections of interior (*), boundary (δ), and exterior (∙) of O with the interiors and boundaries of all rays (rows 1 and 2) and extreme rays (rows 3 and 4). Here * means that there are no rays with such intersection, □ means that some rays have such intersection, and ■ means that all rays have such intersection.

Discussion: In the paper, we have demonstrated that RIM is able to distinguish 28 distinct configurations of three polygon objects (e.g Figure 3), where this number might not be conclusive. We have then applied RIM to triplets of buildings in Parkville campus to analyse which buildings are located between which other buildings.

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