Modeling Intersections of Geospatial Lifelines

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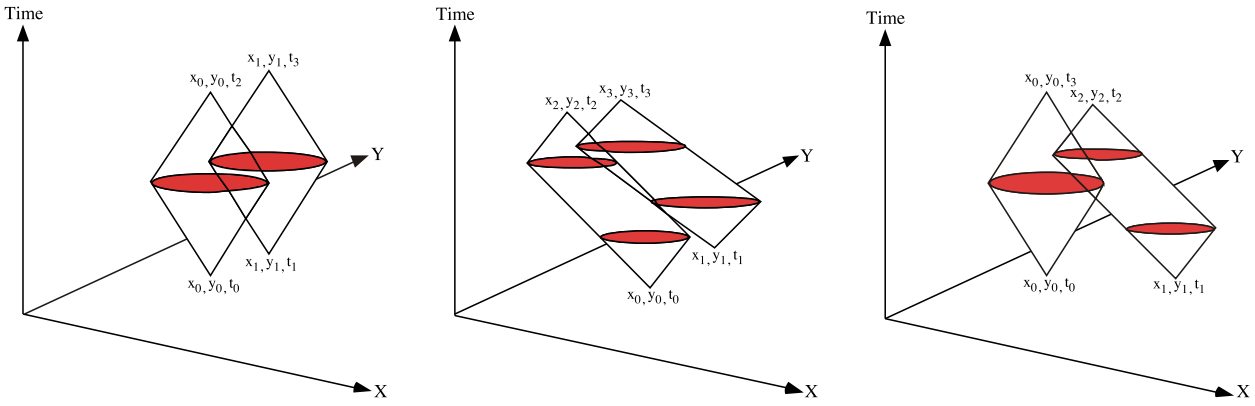
The concepts of Hägerstrand's Time Geography have played an important role in the modeling the movement of individuals over space and time. Geographic information science researchers have applied the geometric approach introduced by Hägerstrand to model the locations that an object occupies while moving (Miller 1991; Forer 1998; O'Sullivan *et al.* 2000). Geospatial lifelines (Mark *et al.* 1999) also use this approach to model movement as a time-stamped record of the locations that an individual has occupied over a period of time. *Lifeline beads* are a particular form of lifeline that model the set of *all possible locations* that an object could feasibly pass through or visit while moving from *A* to *B*. Beads are formed from the intersection of two half cones, pointing in opposite directions. The lower half cone captures the movement of an object from a specified origin (x_0, y_0, t_0), while the upper half cone describes the space-time points at which the object could have been while approaching a second observation sample (x_1, y_1, t_1). The angles in the cones' apexes are determined by the maximum speed at which the individual traveled. This paper describes ongoing work to develop tests for intersections of lifeline beads. Intersections of beads give us more detailed information about the properties of objects' movements and provide more powerful support for query processing. These intersections are relevant, for example, for tracking the spread of contagious diseases among people or for testing alibis evaluating whether two individuals could have met in space-time or traveled the same route together.

There are two types of lifeline beads. When an object's spatial location is the same at two consecutive samples (x_0, y_0, t_0 and x_0, y_0, t_1), the set of possible locations between the samples forms a *right bead*. It is the intersection of two right half cones whose apexes are collocated in space but

shifted in time. If the two half cones are not spatially aligned, then they form an *oblique bead* from the intersection of two right half cones whose apexes are not spatially collocated.

A general method is defined for testing the intersections of any two right beads (Figure 1a), two oblique beads (Figure 1b), or a right bead with an oblique bead (Figure 1c). This method tests for intersections of bead vertices or directrices (the section of the bead originating from the surface of intersection between the two half cones and parallel to the *x*-*y* plane) to determine whether two beads intersect or not.



(a) (b) (c)

Figure 1: Examples of intersections of lifeline beads: (a) intersecting right beads, (b) intersecting oblique beads, and (c) right and oblique bead intersection.

This analysis is further developed through reducing intersections of beads to sections or *slices* in two dimensions. These slices can be points, circles, or regions formed by the intersection of two circles. Intersections of slices give rise to five general classes of intersections and a set of methods that test whether any two slices intersect or not. This approach reduces the complexity of describing intersections of beads in three dimensions and exposes a categorization of possible intersections.

References

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