Implementation of the Temporal Reasoning Algorithm applying General Temporal Relationships

Morishige Ota[1]

[1] Kokusai Kogyo Co., Ltd.

http://www.kkc.co.jp

1. Introduction

GIS has functions to acquire, retrieve, analyze, transfer and represent the spatial information by maintaining the DB of features (abstraction of phenomena in the real world). Features have temporal attributes if they keep their own histories. This paper aims to introduce the implementation of temporal reasoning algorithm applying the General Temporal Relationships (GTR) among features keeping temporal attributes.

2. General Temporal Relationships among Features

Time is one dimensional space in which elements are time points representing occurrences of phenomena. The number of elements in time is infinite by nature. However, as long as we observe phenomena with time points within the certain period of time, we may define that time in a data base is a finite set of discrete elements. While, scales measuring time can classify into 4 types (the nominal, the ordinal, the interval, and the ratio) and different time sets may disjoin, partially coincide, or totally coincide.

The disjoint in the nominal time means non-synchronized, the partially coincidence means partially synchronized, and totally coincidence means totally synchronized as well.

The order is classified into the partially and the totally. The partially ordinal time forms a connected acyclic directed graph (CDAG) in which nodes are time points and edges are order relations between nodes. In this case, the temporal attribute of a feature is an elementally simple path on the CDAG. The temporal relationships between two features may be represented by the relationships between two paths. As a result, we found three types of relationships in the partially ordered time. They are non-synchronized (Type 1), synchronized at one point (Type 2), synchronized at more than one points (Type 3). Type 2 relation has 9 subtypes, and type 3 relation has 16 subtypes (Ota, 2005).

In case of the totally ordered time, we can apply 13 temporal relations defined by Allen(Allen, 1983).

Interval time is a totally ordinal time, as each edge has interval distance. And a distance between arbitrary pair of nodes can be measured. Thus, the CDAG has its own temporal system, but the relationship between different CDAGs is unknown.

We can measure the temporal relations among different CDAGs, if time has its own origin time point. Ratio time is defined as an interval time with the origin point. However, we do not know such an absolute origin point in the real world.

3. Implementation of the Temporal Reasoning Algorithm

Temporal reasoning is defined as the reasoning that estimates the temporal relationships among features. The reasoning algorithm introduced in this paper applies the GTR and time is classified into the nominal, the partially ordinal and the totally ordinal. The program is written in Java and the source code is the freeware and it will be offered by the order to the author from the people who wish to use it.

(1) Reasoning in the nominal time
Input: two sets of time points (e.g. E1={a, b}, E2={c, d}).
Output: relationship between two sets (e.g. E1 is non-synchronized with E2).

(2) Reasoning in the partially ordinal time
Input: Two ordered sets of time points (e.g. E1=(a, b), E2=(a, c)) .
Output: The relationship between two sets (e.g. E1 starts with (Type 2) E2 at [a]).

(3) Reasoning in the totally ordinal time
Input: 1) The ordered set (e.g. T=(a, b, c, d)) of time points, 2) Two subsets of T (e.g. E1=(a, b, c), E2=(b, c, d)).
Output: The relationship between two subsets (e.g. E1 overlaps E2 at [b, c]).

4. References

Ota, M. (2005) The General Temporal Relationships among Features, 9th workshop on Spatial IT, GISA, CSIS at University of Tokyo (written in Japanese)

Allen, J.F. (1983) Maintaining Knowledge about Temporal Intervals, Communications of the ACM, Vol.26, No.11