Spatio-Temporal Relationships in a Primitive Space: an attempt to simplify spatio-temporal analysis

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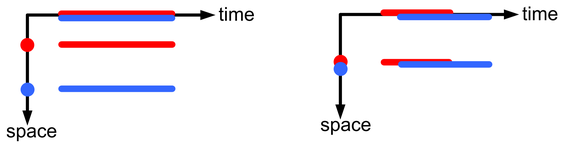
1. Introduction

The improvement of data acquisition techniques has increased the amount of available dynamic spatial data. This provides basic information allowing performing complex spatio-temporal analyses. However, considering time in spatial analyses increases rapidly their complexity. An answer to this assessment can be a generalisation of spatio-temporal relationships. Considering a higher level of relationships abstraction should reduce spatio-temporal analysis complexity. We present a model based on a primitive spatio-temporal space, i.e. where spatial and temporal dimension are not differentiate. We adopted a two step approach; first we combine temporal (interval) relationships and spatial (topological) relationships between objects, and then we generalize theses relationships in a primitive space.

2. Spatio-temporal relationships in a temporal space

Temporal space is a representation of time and space that combine in a common framework spatial and temporal relationships.



Spatial relationships : « disjoint »
Temporal relationships : « equal »

Spatial relationships : « disjoint »
Temporal relationships : « overlaps »

Fig. 1 : Relationships between two points in temporal spaces.

The possible spatio-temporal configurations are presented following the sturcture of temporal spaces with an axis for each dimension as shown in figure 1.
This figure represent two spatio-temporal configurations for two static points in a one dimensional space.

Spatio-temporal relationships between 2 static points in 1D space

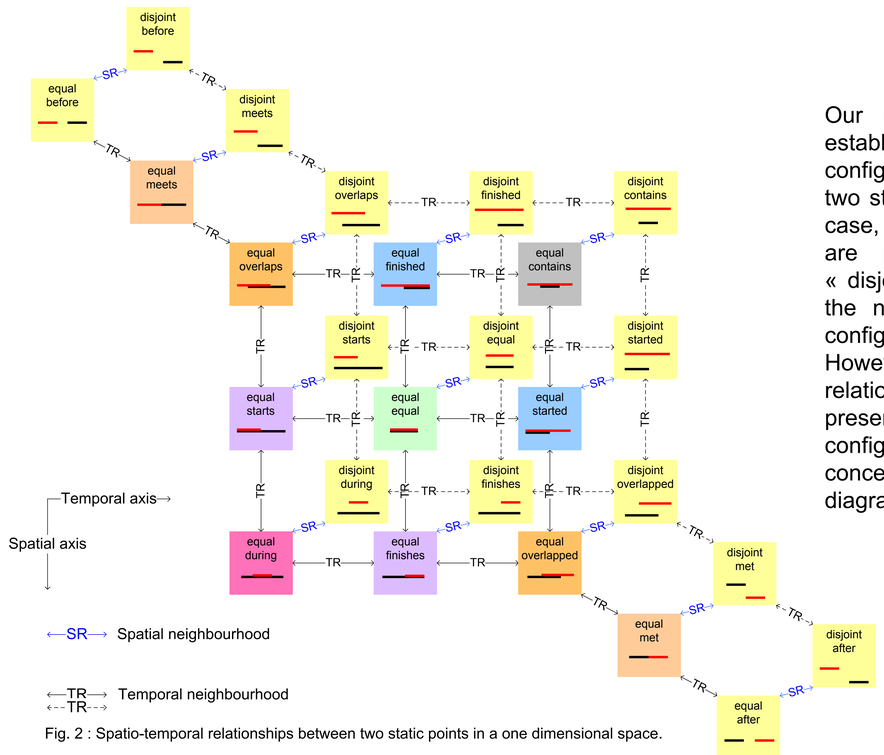


Fig. 2 : Spatio-temporal relationships between two static points in a one dimensional space.

Our research begins with the establishment of spatio-temporal configuration using 1D space with two static points. In this particular case, only two spatial topological are possible; « equal » or « disjoint ». This property reduce the number of spatio-temporal configuration.
However, the thirteen temporal relations are still valid. Figure 2 presents all the possible configuration organised as a conceptual neighbourhood diagram.

3. Spatio-temporal relationships in a primitive space

Working in temporal space may become (too) complex when considering other spatial dimensions (2 and 3) and other types of moving objects (e.g. regions). This is the reason why we wish to investigate primitive spaces as a framework for spatio-temporal representation. In these spaces they are no difference between spatial and temporal dimension. Therefore, we can use topological relationships applied to spatio-temporal objects as a model for spatio-temporal relationships. Such a representation is indeed a cluster of previous temporal spaces representation.

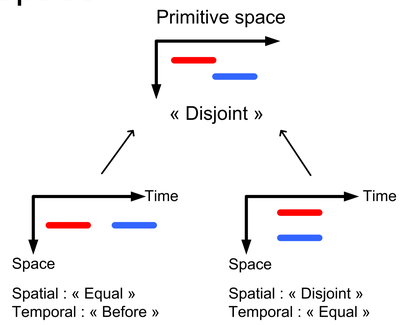


Fig. 3 : Generalization of spatio-temporal relationships in primitive space.

Topological relationships in a primitive space

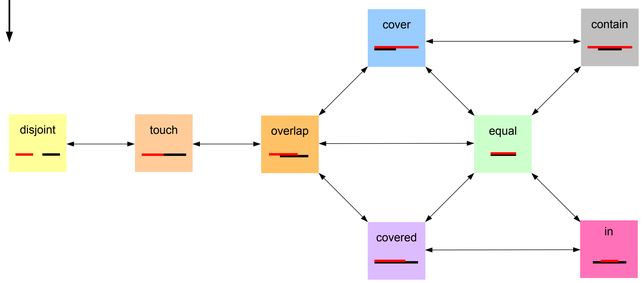


Fig. 3 :Spatio-temporal relationships in primitive space.

We reduce the number of the possible spatio-temporal configurations to a small set of well-known topological relationships. Figure 4 presents the model for two static points. In this case, we move from 26 spatio-temporal relationships to 8 topological relationships in a primitive space. The colors represents the generalization we made from figure 2.

4. Perspectives and conclusions

This model has been extended to 2 moving points in a 1D space. In this case, we can exclude some topological relationships that are impossible if we consider that no returns in the past are possible (see figure 5).
Working in a primitive space, we are able to describle all possible topological relationships between two spatio-temporal history for two moving points. Figure 6 presents an extract of all possibilities.
This model seems to contain enough spatio-temporal information to perform spatio-temporal analyses. We believe that it could reduce analysis complexity.

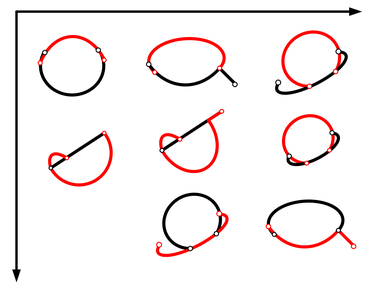


Fig. 5 : Impossible spatio-temporal relationship between two moving points.

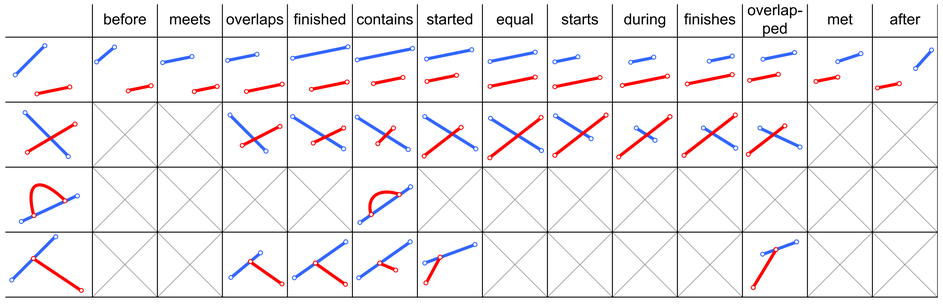


Fig. 6 : Extract of spatio-temporal history relationship between two moving points.