Semantic Topological Change

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1 Motivation

Qualitative spatial reasoning has emerged as a promising method which is helpful in reasoning about spatial relations among objects. This methodology facilitates a system which excludes the need to resort to quantitative representations of spatial relations, making the method a widely acceptable standard in the realm of geographic information science.

Conventional methods of capturing qualitative spatial relations among objects have largely relied on the relation's conceptual neighborhood graph. Through years this approach has proven to be extremely useful in making pragmatic and reliable inferences on the object's relations. So far a minimum level of attention has been paid towards capturing the semantics among different objects. This has introduced difficulties describing relations among objects which have different semantics. Due to the unique relations which result specifically owing to the nature of the interacting materials it would be highly desirable to capture them in some representation which would exceed the capacity of capturing different semantics of objects in conventional neighborhood graphs. Depending on the types of interacting materials, the cardinality of the set of relations could vary significantly. Attempting to represent different configurations similarly would suggest the ontological differences among different objects are not adequately taken in to account and thus results in a misrepresentation of the reality rendering the inferences unreliable.

2 Spatial Relations

Spatial relations among objects vary based on the dimensionality of the embedding space. This research focuses on binary topological spatial relations that are plausible in $\mathbf{S}^2$.

Depending on the types of the objects that interact, two classes of spatial relations can result: spatially compatible spatial relations and mutually exclusive spatial relations.

2.1 Spatially Compatible Relations

When two simply connected objects are capable of making spatially compatible relations eleven topological relations can result in $\mathbf{S}^2$ [1, 2, 3]. Each of the eleven topological relations has ten other relations which could be considered as the closest relationship based on their topological distances [4]. Considering relationships as nodes and the possible changes as edges, topologically closest relationships could be connected and the resulting graph is called a *Conceptual Neighborhood Graph*.

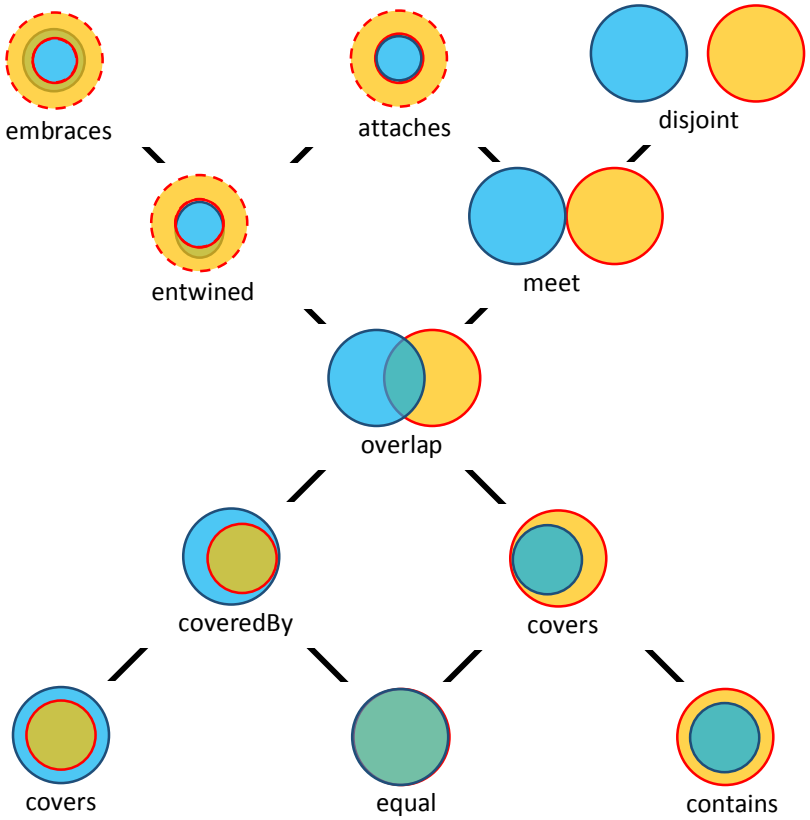

Figure 1 Neighborhood graph for spatially compatible topological relations of objects in $\mathbf{S}^2$.

The relations are jointly exhaustive. Therefore, for any two simply connected regions at least one relation out of the eleven relations are applicable. Depending on the shape of the object, such as whether an object has a cut, a piercing, a hole or a separation, additional binary spatial relations can result.

2.2 Mutually Exclusive Relations

If two objects are mutually exclusive in $\mathbf{S}^2$, the set of relations which can result is very much limited and is a sub set of the relations that can result when the objects are spatially compatible. Following is the neighborhood graph for the set of relations for mutually exclusive spatial relations between simply connected regions in $\mathbf{S}^2$.

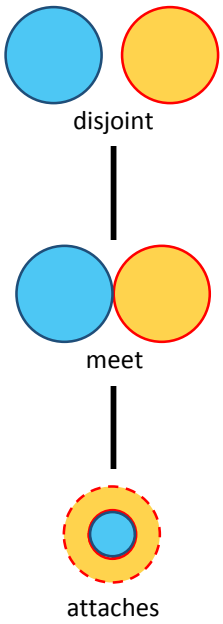

Figure 2 Neighborhood graph for mutually exclusive topological relations of objects in $\mathbf{S}^2$.

3 Classification of Objects

Objects could be broadly classified in to bona-fide and fiat objects. Bona-fide objects are characterized by physical discontinuity or qualitative differentiation of matter while fiat objects are characterized by objects which are identified as separate entities by humans; physical discontinuity or qualitative differentiation is not essential for such a characterization [5].

3.1 Fiat Objects

All relations with fiat objects are spatially compatible. All eleven region-region relations apply whenever at least one of the related regions is a fiat object. However if two fiat objects are of the same ontological kind the objects can not result in an overlap. For example the boundaries of two countries do not overlap. Further changes to fiat objects are instantaneous and discrete. For example United Nations came into existence immediately after the ratification of the charter by the first fifty governments and grew by size as and when other nations joined the organization.

3.2 Bona-Fide Objects

Bona-fide objects could be further classified into four different categories based on the states of matter in which they exist on the earth: solids, liquids, gases and plasmas. Further changes to bona-fide objects are gradual and continuous in contrast to that of fiat objects.

3.2.1 Solids

Solids have a definite shape and a volume owing to the high level of inter molecular attractions. This fact prevents solid objects from overlapping; surfaces of solid objects can come in to contact but they cannot mix, resulting in a shared boundary (considering shorter periods of time). Therefore solid objects always result in mutually exclusive spatial relations.

3.2.2 Liquids

Liquids have intermolecular attractions that are much lower than the attractions found in solids. Levels of molecular energy is not sufficient enough to liberate a liquid molecule completely from the attractions it has with neighboring molecules. Hence liquids demonstrate a fixed volume but a variable shape. Liquids are of two types: inviscid liquids and compatible liquids. Inviscid liquids result in mutually exclusive relations while compatible liquids mix with other compatible liquids resulting in mixtures.

Further solids and liquids always result in mutually exclusive spatial relations owing to the same reason which prevents solids from overlapping with an object of the same kind: high inter molecular attractions.

3.2.3 Gases and Plasmas

Gases have very weak inter molecular attractions and high levels of molecular energy. Hence gases have no definite volume or shape. On the other hand plasmas are ionized gases.

4 Future Work

Spatial relations that can result in liquids, gases, plasmas and combinations of those states of matter (including solids) are still at experimental state. We are currently exploring the types of spatial relations that can result with such matter in crafting a theory of topological change.

5 References

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