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Extending the MultiDim conceptual model to enable the design of vague spatial data warehouses

Spatial vagueness is one kind of spatial data imperfection concerning the difficulty of distinguishing an object's shape from its neighborhood [1,4,5]. For instance, given an agricultural disease that is transmitted by an insect, for a certainly infected tree, the neighbour trees within a distance are possibly infected (perhaps with a degree between 0 and 1), while trees far away are merely not infected. Exact models [4], fuzzy models [1] and data structures for fuzzy models [5] define vague spatial data types, operations (e.g. union) and topological relationships between vague spatial objects. Recently, the VSCube conceptual model has enabled the conceptual modeling of vague spatial data warehouses (vague SDW) and provided flexible and multidimensional ways for representing, querying and aggregating vague spatial data [6]. However, the VSCube conceptual model does not offer graphic representations of the concepts, which could be utilized by database designers. Thus, one of the objectives of this doctoral thesis, which is addressed in this paper, has been to enable graphic representations for the conceptual modeling of vague SDW. In order to achieve such objective, the MultiDim conceptual model [2], which is presently suitable for the conceptual modeling of crisp SDW, was extended to reuse formal definitions of the VSCube conceptual model. The first extension encompassed the creation of new pictograms for attribute types and levels, such that: (i) data types were distinguished without ambiguity, i.e. vague point, vague line and vague region; (ii) the three-valued logic (true, maybe, false) employed by exact models [4] was differentiated from the fuzzy logic used by fuzzy models [1]; and (iii) drawing was feasible using only pencil and paper to comply with elementary usability principles [3]. As a result, the pictograms for vague points, vague lines and vague regions represented by exact models are black and dashed, while the pictograms for vague points, vague lines and vague regions represented by fuzzy models have grayscale similar to gradients. The second extension concerned the elaboration of a notation for topological relationships that exist in hierarchies. Then, the same pictograms used by the MultiDim conceptual model were maintained. Nevertheless, instead of placing a single pictogram to denote the topological relationships allowed between members of the child level and the parent level, one matrix containing pictograms should be placed to relate parts of the members of each level. These parts are the certitude and the dubiety, as defined by the VSCube conceptual model, which refer to the part that certainly belong to a member and the part that possibly refer to a member, respectively. One pictogram represents the topological relationships allowed between the certitudes of the members; one pictogram represents the topological relationships allowed between the certitude of members in the child level and the dubiety of members in the parent level; one pictogram represents the topological relationships allowed between the dubiety of members in the child level and the certitude of members in the parent level; and the last pictogram represents the topological relationships allowed between the dubieties of the members. In order to show the applicability of the aforementioned extensions, a vague SDW regarding the infestation of an agricultural disease was modeled with hierarchies, dimensions and fact relationship. As future work, we intend to provide graphical representations for topological relationships that exist in fact relationships as a result of more than one spatial dimension [2], and for the vague spatial fact to associate values of measures to parts of vague spatial objects [6].

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References

1. Dilo, A., de By, R.A., Stein, A.: A System of Types and Operators for Handling Vague Spatial Objects. IJGIS 21 (4): 397-426 (2007).
2. Malinowski, E., Zimányi, E.: Advanced Data Warehouse Design: From Conventional to Spatial and Temporal Applications. Springer (2008).
3. Nielsen, J.: Usability Engineering. Morgan-Kaufmann (1994).
4. Pauly, A., Schneider, M.: VASA: An algebra for vague spatial data in databases. Inf. Syst., 35, 1, 111-138 (2010).
5. Schneider, M.: Spatial Plateau Algebra for implementing fuzzy spatial objects in databases and GIS: Spatial plateau data types and operations. Applied Soft Computing 16, Março, 148-170 (2014).
6. Siqueira, T. L. L., Ciferri, C. D. A., Times, V. C., Ciferri, R. R.: Modeling Vague Spatial Data Warehouses using the VSCube Conceptual Model. Geoinformatica 18 (2): 313-356 (2014).