Characterization and Combination of Agronomical Entities in Accordance with Spatial and Quantitative Imprecision

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ABSTRACT

One of the objectives of the authors’ studies on the monitoring of agricultural practices is to deal with imperfect spatial and quantitative information, and to always associate a quality evaluation with acquired or computed data from each location in the territory being studied. In order to produce quantitative information for each location and to consider the imprecision of data, this paper introduces the notion of fuzzy agronomical entities that consider both fuzzy spatial and quantitative information. Then, it proposes a new approach for propagating spatial imprecision to fuzzy quantitative values using two fuzzy combination operators. This method produces the fuzzy quantity of spatially disseminated chemicals for each location.

Keywords: Agronomical Data, Fuzzy Agronomical Entity, Fuzzy Combination, Imprecision Modelling

1. INTRODUCTION

In the past 30 years, the use of the Geographical Information System (GIS) has grown, and today it is the standard for managing spatial – as located on Earth – and spatiotemporal data. Its uses range from archaeology (De Runz and Desjardin, 2010) to agronomy (Miralles et al., 2010).

In the whole GIS process, the modelling, the storage, and the treatment of data conduct to question the quality of data and treatment and therefore their possible imperfection. Information or data is perfect when it is precise and certain. Imperfection can be due to imprecision, inconsistency and uncertainty, the major aspects of imperfect data. There is imprecision whenever the exact value of the

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truth status of a proposition of interest is not established uniquely, i.e., whenever its truth status is equivocal (Smets, 1995).

Indeed, the construction of a unique set of entities implies the combination of information coming from multiple sources. By observing and modelling reality, the building of each source dataset includes some imperfections. The data integration also produces other imperfections. The built entities thus induce at least some imprecision/uncertainty in the definition of spatial features and quantitative attributes (Shi, 2010).

In spatial science, a principal issue is how to deal with boundaries: it is hard to precisely and accurately delineate frontiers (Burrough and Frank, 1996; Fisher 1999). Even though the use of GIS for the management of agricultural pollution has been common (Morse et al., 1994), the consideration of data imprecision, from the modelling to the additive effects in the boundary areas, is still a current issue and is the subject of this work.

As the aim of our system is to give interpretable information in each location of the monitored space, we choose to use fuzzy data modelling for both spatial and quantitative values. Nevertheless, the fuzzy set theory allows overlaps between fuzzy shapes. In this case, the question is: what is the value of fuzzy quantitative attributes in a location where two or more fuzzy spatial shapes overlap?

This paper introduces the notion of the fuzzy agronomical entity, which combines a label, a fuzzy spatial shape, and fuzzy quantitative attributes. Using this definition, we study the propagation of spatial imprecision to quantitative attributes.

We focus on the combination of both spatial membership and quantitative information for computing a fuzzy quantity of spread product in a parcel.

The paper is structured as follows. Section 2 is devoted to the presentation of the context: (i) the project Observox and (2) the issues and the main approaches of modelling imprecise data in GIS. In section 3, the notion of the fuzzy agronomical entity is introduced. Section 4 studies the consequences of spatial overlapping through the definition of operators corresponding to our context (additive effect, and fuzzy agronomical entities). The following section (5) describes a simulated case study. Finally, some concluding remarks and future perspectives are discussed in section 6.

2. CONTEXT

2.1. The Observox Project

In the sustainable development context, the AQUAL project (a State-Region Project in the Champagne-Ardenne, France) highlights the need for a monitoring environment for the study of agricultural practices and their pressure on the water resources in the Vesle basin, France. The main objective of the monitoring system, called Observox, is to study the practices responsible for pollution, using an information system built by researchers, institutions and farmers. The system records the area diffusion, the nature, and the quantity of disseminated chemicals, and how these factors are linked with the evolution of the agricultural system in the studied region.

The Observox system uses data coming from heterogeneous sources: satellite images, land registry, statistical data, Corine Land Cover and other European data. The final data are also multivariate because many factors are studied (many chemicals are used) for each field/area. The quantitative values allow us to characterize the area.

We first compute the parcel delineation according to both raster and vector data. This computation implies some imprecision. Therefore, we choose to store the parcel spatial shape as a fuzzy shape. The fuzzy shape could be defined either as a raster or as a vector data, but the storage cost conducts us to choose the vector format (de Runz et al., 2010). As the chemical quantities are obtained according to survey and polls, the quantities associated to each parcel are also imprecise and, thus, modelled as fuzzy numbers.

The main goal of the system is to monitor the quantities of chemicals spread over each location of the observed territory in order to
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