Using fuzzy set theory in Geoinformatics

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The real world or real phenomena can be defined either precisely or by means of model representations (descriptions, images, mathematical, information models). The model can not coincide with the original due to the large number of uncertainties, complexity, fuzzy definition of the real world. For the interpretation of uncertainties sometimes use the laws of statistics and the concepts of probability and reliability.

Geospatial features in models are typically described by previously defined properties. Applying the rules of logic and mathematics, in the mathematical model operate on these objects, dividing them into two groups: satisfy/do not satisfy the selected rule, "Yes" or "no" - the third is not given. These provisions do not allow overlapping classes, partial truth, partial membership of the set.

However, geospatial phenomena are described by many interrelated attributes, and their study must consider their attributes in relation. The ways of such interaction are unpredictable, so there is a need to apply the concept of fuzziness to geospatial information.

In geographical studies, GIS users usually have a clear understanding of their purpose (for example, land assessment or planning objectives are clearly defined). But they often are not sure where exactly should be the boundary between the classes of individual types of objects, which is inexact (or fuzzy) identify requirements should then translate in terms of the spatial objects in the database. In addition, not all information is accurate: already in the primary measurements are used fuzzy certain terms and attributes (for example, "soil, well-drained"). Therefore, you need methods to work with uncertain requirements, classes, boundaries.

Fuzziness allows for the possibility of membership, the assessment of which is based on subjectivity, intuitive or expert knowledge, but can correspond to a clearly defined uncertainty, for example, the probable measurement error of some size.

Standard, or clear, sets allow only binary membership - 0 or 1. In terms of fuzzy sets, the degree of class membership is expressed in terms of scale, which can vary continuously from 0 to 1.

In many cases, clear class boundaries are defined by their attributes in two ways:

- construction of discriminant (separating) functions using expert knowledge, some regularities, requirements; here it is only necessary to set the upper and lower boundary of the class;
- numerical taxonomy, such as clustering.

Such paths are also applicable for fuzzy sets, for determining the boundaries of which the discriminant functions MF(z), called "membership functions" are constructed.

For fuzzy sets, the membership functions are chosen so that the degree of membership of the dimension to the set at its center is 1, falls in some way to the fuzzy boundary, and takes the value 0 outside this boundary. The point at which MF=0.5 is called the transition point.

The simplest MF are linear functions, which are defined by a pair of inclined lines intersecting at MF=1 at point c, located in the center of the set, and at MF=0.5 crossing its boundaries. The slope of the lines defines the width of the fuzzy transition zone. The area between the sloping lines and the outside of the Boolean rectangle is called the zone of partial truth.

Many decision-making areas depend on the accumulation of expert knowledge and experience. The value of geospatial information especially increases with the use of software based on the technologies and methods of artificial intelligence and expert systems. They are intended for storage and use of special knowledge, comparison between themselves final and intermediate conclusions. This is especially important when operating with fuzzy sets and fuzzy knowledge.

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