OHE OBJECT ORIENTED ANALYSIS AND EVALUATION METHOD FOR THE NATURAL DISASTER BASED ON SPATIAL TECHNIQUES: A PILOT STUDY

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ABSTRACT:

Some different techniques were adopted in disaster management and research. Difficulties appeared in operational disaster emergency response works. There is no effective scheme to integrate various methods to a system considering that big difference exist among different disaster happening environment. Considering OHE as the unification of objects having relationship with natural disaster, we put forward a hypothesis that different analysis and assessment method of natural disaster would be integrated together based on the OHE object under the technical framework of GIS. Taking flood disaster as a case study, a pilot study was carried out. Designs of the basic technical framework, data model of objects were included in the detailed experimental works. Some conclusions were received during the pilot study.

1. INTRODUCTION

Considering the risk assessment method for natural disaster, researchers all over the world carried through various researches and practices. Different directions were aimed at and different techniques were adopted in these processes of studying. Applied mathematics, management science, geography, hydrology were used to develop practical method such as hazard analysis of disaster inducing factors, vulnerability analysis, loss assessment, et al. However, difficulties still come forth during the operational disaster emergency response works. There is not any effective scheme to integrate above various methods to a system considering big difference exists among different disaster happening environments. In other words, the integration ability of existing methods was absence. It blocked the development level of natural disaster analysis and assessment.

A new method of analyzing and evaluating the natural disaster based on OHE (Object of Hazard) object was brought forward in this paper. It was founded on the technical base of the theme oriented multi-temporal differ-structural spatial data management and service (HU, 2007). The ultimate goal was to serve for the operational work of natural disaster emergency response.

The premise of this scheme is considering OHE as the unification of all objects having relationship with natural disaster. On the basis of this premise, considering the advantage of GIS spatial analysis and the spatial attribute of OHE object, we put forward a hypothesis that different analysis and assessment method of natural disaster would be integrated together based on the OHE object under the technical framework of GIS. To verify this hypothesis, two problems should be accounted for. They are the technical foundation and the object model foundation.

Taking flood disaster as a case study, we carried out a pilot study of above idea and scheme. Designs of the basic technical framework, data model of objects were included in the detailed experimental works. A testing environment was built under the help of ArcGIS desktop software, visual studio 6.0 programming platform and ATL 3.0 COM technology. A mixed data structure (raster and vector) was designed to enhance the flexibility of OHE object analysis. Good effect was got during the application in the process of operational works.

2. TECHNICAL FRAMEWORK

Figure 1 shows a basic framework of OHE object based analysis and evaluation method for natural disaster.

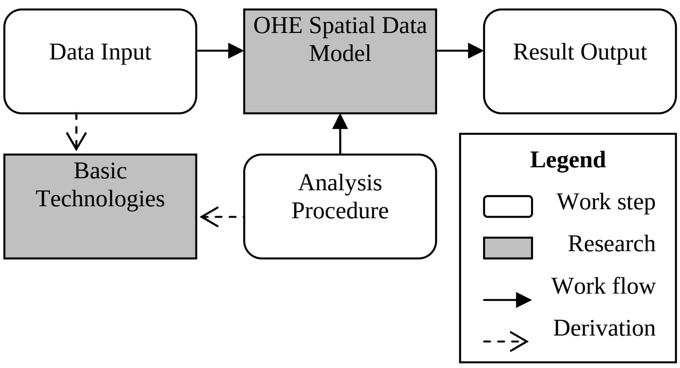


Figure 1. A basic framework of OHE object based analysis and evaluation method for natural disaster.

This framework utilizes the unification characteristics of OHE object. The analysis or evaluation process can be defined and divided into three parts generally, including input, analysis / evaluation, and output. It abstracts, simplifies and unites the contents of natural disaster management. Under this framework, appropriate data model and technologies applied in the process of information flow and analysis were considered as problem to be tackled at first. The data model is to be discussed in section 3.

To make discussion convenient, we organized the information flow as four continuous phases, according to the theory put forward by Huang (Huang, 2006). They are cause phase (f1), medium phase 1 (f2), medium phase 2 (f3), and result phase (f4).

2.1 Technical Basis for Risk Analysis

It aims to evaluate the intensity of disaster inducing factors for those natural disaster events tend to appear (Huang, 2005). Probability, statistics and fuzzy method are considered as basic method. Meanwhile, aiming the complexities, new theory for disaster risk analysis based on non-maturity information and information diffusion technology was put forward (Huang 2005). These methodologies, not only conventional ones but also advanced ones, are usually not combined with spatial information methodologies. As a result, models can be run to get degree of risk directly, which will be input as important information source in an integrative operational system built on spatial information framework.

A mature middleware (function component) will be utilized to realize risk analysis and calculations (f1). Strength of disaster risk can be acquired. The problem to be solved, considering the requirement of system integration, is the transfer of risk strength value parameter.

2.2 Technical Basis for Vulnerability Evaluation.

Taking flood disaster as an example, vulnerability evaluation is defined as the possible loss of OHE under a certain social economic condition and affected by the flood disaster with different degree. It is a complex and integrative process. The principal requirement is to find an appropriate indices system and build influence function between indices system and OHE vulnerability. Indices system can be divided into three principal parts: risk of disaster inducing factors (input from risk analysis, f1), environment of disaster developing, and OHE social economic conditions. All sorts of information (including field measurement, questionnaire, statistics, analysis, and so on) will be input into a integrative function to get vulnerability of OHE.

The indices system and the function of “indices-vulnerability” relativity can be built by method of field investigation, questionnaire, analysis, and son on. Some methods like multi-factor relativity analysis, AHP, ANN, fuzzy estimation were involved.

At the same time, the realization of OHE vulnerability evaluation is usually based on GIS spatial analysis. Essence of OHE vulnerability evaluation is the calculation of a quantitative or qualitative attribute of OHE on the basis of some indices. It results in that “layer overlay” becomes the main type of spatial analysis method to be used. According to the different characteristics of vector and raster data, principal methods were listed in table 1.

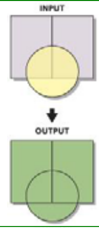
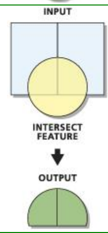
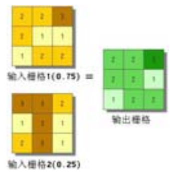
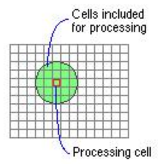
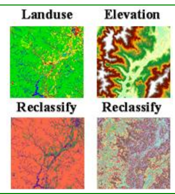
Applicable Spatial Data	Function	Figure*	Purpose
Vector	Union		According to the requirement of analysis and evaluation, segment and reorganize original OHE object with different attribute (index value) to form derived OHE object.
	Intersect		
Raster	Weighted Overlay		Overlap raster layers to calculate a new OHE attribute value for every cell considering weights.
	Map Algebra		Provide mathematical interface to calculate cell’s attribute value
	Neighborhood		Provide interface to calculate surface parameters may used in analysis.
	Reclassify		Standardize different indices to a same value range.

Table 1. Principal spatial analysis function used in vulnerability evaluation

Vulnerability analysis takes OHE as carrier. It is implemented on the basis of spatial analysis method. So, the integration is convenient and easy.

2.3 Technical Framework of Loss Assessment

Loss assessment calculation the damage of OHE according to the actual disaster intensity (e.g. amount of flood peak, inundation depth, inundation time and flow speed n the case of flood disaster). It reveals as the function of “disaster intensity and OHE attribute - damage” (f3). The storage and implementation of this function is the principal problem to be tackled in the process of integration (f4).

* Figures from ESRI ArcGIS Desktop 9.1 Help

2.4 Integration Methodologies

On the basis of above ideas, it was concluded that the integration can be converted to the problem of information expression and transfer. It includes expression and transformation of parameters and functions. Knowledge library can be a complementary method if both of these two methods can't be used.

(1) Expression and transfer of parameters. Two ways can be considered. First of them is storing parameter values into database and using it as input parameter of other functions (fx, x = 2, 3, 4). The other one is assigning parameter value as attribute of OHE object which is derived from spatial features. It will take part in the attribute calculation in the process of analysis and evaluation.

(2) Expression and transfer of function. Standard programming interface can be designed and developed by computer programming language to wrapping functions. With the help of unique identifier (ProgID), all functions can be called in a consistent form. Spatial OHE object (formed from GIS spatial features) can record their appropriate analysis and evaluation functions in attribute tables. Following codes show a pseudo-procedure to call analysis function of OHE object.

```
IOHEObject pObj;    // OHE declaration
IFunction pFunc;    // function interface declaration
Set pFunc = CreateObject(pObj.FuncID);    // create function object by ProgID
pFunc.Call(pParaList);    // call function
```

(3) Knowledge library. Considering some information processes may not or may difficult to be implemented by parameters and functions, knowledge library was chosen as a complementary method to express and transfer information. "Indices - result" relation knowledge table can be designed and built (table 2, in case of flooding damage rate of drought crop). One or more tables form a whole knowledge object. Knowledge library object is controlled by a single table to facilitate the management process. On the other hand, standard knowledge library object interface and query interface are implemented. They can be used to implement the information derivation in the process of OHE analysis and evaluation.

depth / crop	<0.5	0.5~1.0	1.0~2.0	2.0~3.0	>3.0
Wheat	25	75	100	100	100
corn	35	90	100	100	100
durra	25	88	100	100	100
millet	55	100	100	100	100
soja	50	100	100	100	100
vegetable	55	100	100	100	100
others	50	100	100	100	100

Table 2. Flooding damage rate of drought crops (%)

Table 2 is a flooding damage rate table of drought crops. Some similar tables can be stored in database to construct one or more complex knowledge. Knowledge library object, knowledge condition object and knowledge object are considered three core objects in the architecture of knowledge library programming (figure 2). They provide knowledge library connection, knowledge object realization, query condition management, knowledge query and some other functions. Knowledge query can be realized by inner SQL of relational database. For example, below sentences can be used to find the flooding damage rate of wheat when inundation depth is less than 0.5 meter.

*select * from [TABLENAME] where wdepth = 0.5 and type = 'wheat'*

The calling of programming object is demonstrated as following codes.

```
IKLibrary pKLib;
IKObject pKObj;
IKCondition pKCon;
pKLib.Connect();
pKObj = pKLib.CreateObject("Agriculture");
pKCon.AddCondition("wdepth", 0.5);
pKCon.AddCondition("type", "wheat");
drate = pKObj.Query(pKCon);
```

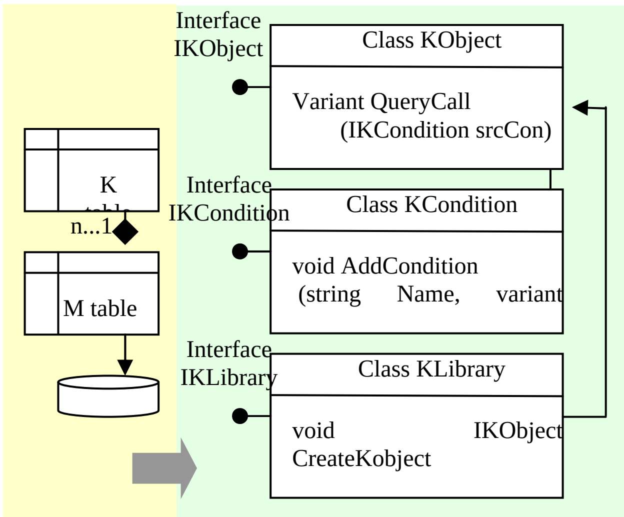
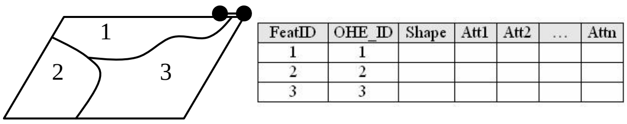


Figure 2. Architecture of knowledge library programming object

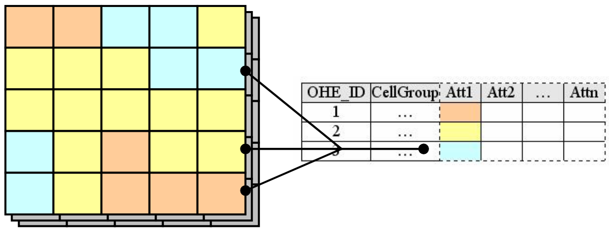
3. OHE OBJECT DATA MODEL

GIS spatial data was chosen to be the carrier of OHE object. It defines the location and extension of OHE object. On the other hand, it records the attribute to be applied in analysis and evaluation, including natural, social and economic.

Basic or thematic layer can be used to acquire geometry and attribute information of OHE object from spatial database. To meet the requirement of integrative characteristic, it is implemented that both vector and raster layer can be used to build OHE object. To vector data, a separate OHE object corresponds to a geometry feature. The attribute of OHE object is recorded in data table attached with vector layer. To raster data, an OHE layer is compose of one or more raster layers. Cells having same value in different band (name cell group) form a separate OHE object. It is not require that cell group must be spatial continuous (Figure 3).



(a) OHE layer built on vector data，one feature forms one OHE object



(b) OHE layer built on several raster layers, cells having same value in different band form a single OHE object

Figure 3. Spatial data foundation of OHE object

4. EXAMPLE

Information in table 2 was used to introduce the procedure of analyzing flooding loss of drought crops based on OHE object and knowledge library.

(1) Data preparation. It is required to produce land use layer using remote sensing data.

(2) OHE layer building. Parcel features in land use layer are the spatial carrier of OHE object. OHE management tool can be used to build OHE layer. The attribute table can be defined as table 3.

OHE attribute	Vector data attribute
Crop type	CropType
Crop area	Shape_Area
Output anticipated	PProdValue
Inundated depth	FloodDepth
Damage rate	DamageRate
Loss predicted	PLost

Table 3. Attribute definition of OHE object

In table 3, the inundation depth value should be got according to the real-time remote sensing monitoring data and under the support of DEM data. The result will be stored in this table as OHE object attribute.

(3) Programming to implement loss assessment model. OHE object will be got at first. Then, knowledge library object will be used to update the damage rate value of every OHE object (f3). Pseudo-codes were listed below.

```
for(i = 0; i < OHENum; i ++)
{
   …
   pKCon.AddCondition("wdepth",
pOHEList.GetOHE(i).GetAttr("InundationDepth"));
   pKCon.AddCondition("type",
pOHEList.GetOHE(i).GetAttr("CropType"));
   pOHEList.GetOHE(i).SetAttr("DamageRate",
pKObj.Query(pKCon));
}
```

The loss value will be calculated for every OHE object and stored in to OHE attribute table.

```
for (i = 0; i < OHENum; i ++)
{
   double dArea, dProdValue, dRate;
   dArea = pOHEList.GetOHE(i).GetAttr("CropArea");
   dProdValue=pOHEList.GetOHE(i).GetAttr("OutputAnticipated");
   dRate = pOHEList.GetOHE(i).GetAttr("DamageRate");
   pOHEList.GetOHE(i).SetAttr("LossPredicted", dArea * dProdValue * dRate);
}
```

Above procedure was organized in object-oriented (OO) form. It fit for the idea of operational job. It was easy to be understood and implemented. To other disasters and working contents, it can be also developed according to the same standard procedure. The difference may exist in the choice of information expression and transfer method.

5. CONCLUSION

Some conclusions were received during this pilot study. (1) Not only raster data but also vector can be used in this scheme based on OHE object. It made the data integration available as well as the technology integration. (2) This method has applicable features including object oriented and service oriented. (3) As a technical framework having flexibility and extensibility, OHE based method can be used to not only integrate the existing technologies into an integrated framework, but also design and develop some new excellent method of calculation, analysis and assessment.

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