A Review on AI and ES in Soil and Water Conservation of China

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For centuries, mankind has been heavily perplexed by soil and water losses ,which has been one of the top ten environmental problems worldwide. The governments all over the world have increasingly paid high attention to the control of soil and water losses, and researches on soil and water losses and their principles have been carried out. Soil and water losses are the integrated outcomes resulted from the interactions of natural, social and economic factors. It is an opening and gigantic system with complexity. Limited by the developing level of sciences, early researches on soil and water conservation were conducted qualitatively. With the development of the technologies of computer science and other modern scientific methods, the researches have stepped into the semi-quantitative and quantitative level. In 1940s quantitative analysis was applied to the researches on soil and water losses in China(Yangqinke *et al*.,1998).In early 1980s,statistical analysis was used to estimate soil erosion(Mujinze *et al*.,1983). With the development of quantity campaign, physical patten has been introduced to establish the model of mathematical statistics and mathematics to quantitatively describe the development and principles of variation of soil and water losses. At the end of 1980s, Chinese scholars set out to establish physical prediction models of soil erosion(Cai Qiangguo *et al*.,1996).However, these models were prevented from further development for lacking real-determined datas and parameters.

The rapid development of the technologies of computer science and spatial information have provided new methods to the researches on soil and water conservation. Since 1990s ,the applications of remote satellite image, digital map and geographic information system have considerably improved the ability to solve problems and accelerated the development of the science of soil and water conservation .

Metasynthesis, proposed by Qianqicheng, the famous academician of Chinese Science Academy is a kind of synthesis from qualitiveness to quantitiveness for opening and gigantic systems with complexity. It is an important guide for the quantitative researches on soil and water conservation. More and more people are aware of the importance of quantitative studies. And Artificial Intelligent ,especially Expert Systems are considered to be helpful, because they are powerful in dealing with the non-structural problems .

1 Integration of ES,GIS and DSS

1.1 Expert system

In 1965,the first expert system, DENDRAL was borned (Feigenbaum, 1977). DENDRAL is able to infer the molecular structure according to the molecular formula of chemical combination and mass spectrographic datas. The invention of DENDRAL has made significant progress in the field of AI. And the technology of ES is thus widely applied to many fields of science (Yang Xueshan, 1992) including chemistry, medicine, army, geology, management etc.. In terms of the main charicteristics of functions and structures, Expert Systems could be classified as follows: (1) Heuristic Expert System; (2) Real-time Expert Controls (Xiong Fanlun, 1992); (3) Models-based Expert Systems (Li Zhong, 1991); (4) Expert Databases; (5) Problem Specific Shells.

1.2 Integration of ES and GIS

GIS refers to a software that could put datas discribing the objective world into computer according to the geographic coordinate or spatial coordinate. It has multi-functions of saving, modifying, searching, indexing, caculating, processing and outputing. Resently, GIS has been widely used to investigate,

estimate and map soil erosion, dynamically monitor soil and water losses, establish quantitative estimation model, develop soil and water conservation information management system and so on (Li rui *et al*., 1998).

Generally speaking, there are two ways for the integration of ES and GIS. One is the tight coupling, the other is the loose coupling (Zhang Hongliang, 2000).The formmer refers to applying the knowledg expression and reasoning mechanism of expert system to transform the inner data's model and data's structure of GIS and create a real intelligent GIS. While the latter refers to the outside combination of GIS and ES, where both share the same interface and combine with each other through medium files. In the combination, GIS is used to form spatial databases as well as a tool for spatial analysis and display, while ES is utilized to produce knowledge database and make heuristic reasoning with reasoning engine of ES. Compared to tight coupling, the latter is wider in use because it is more simply and easier for development.

1.3 Integration of ES and DSS

DSS is a kind of supporting dicision-making knowledge information system, based on the technologies of computer, which is used to solve the semi-structural and non-structural problems in dicision-making process.

At present, many reasearches on the combination of ES and DSS have been under way, which have promoted the development of IDSS and ESS (Najdawi E.I *et al*., 1995).ES combines with different parts of DSS or be an attachment of DSS. In both situations, ES is considered as an intelligent aid for DSS (Hui Shaowen *et al*., 1995), such as Intelligent Dialogue Interface for Cutting, Intelligent Data Management and Intelligent Model Selection. Many related systems have been developed in different fields. For example, Pine Moth Intelligent Forecast Expert System (Chen Wenwei, 1998),Intelligent Decision Support System for Eco-Economi Forestry (Fu Shuxue, 1994), Decision Support System for Land Use (Shi Mingchang *et al*., 1998).

2 ES combing with other new technologies

2.1 Synergism of expert system and neural networks

Neural Networks, based on the organ of human's brain, enable to make numerous neural cellos which have similar structures and functions connected with each other and form a complicated network to realize complicated intelligent beheavior. Neural Networks has powerful ability of self-learning and could automatically study knowledge of given fields from training samples. Synergism of Expert System and Neural Networks has been an important trend for the development of AI (L.R. Medsker 1991). There are some progresses made in theories and applications .There are two points in theories, one is Connectionist Expert System(S.I.Gallant,1988,1993) ,that is expert system based on neural networks, the other is Expert Networks (D.C. Kuncicky *et al*.,1991;R.C.Lacher *et al*.,1992).In China related researches have been undergone such as the Matesynthesim of Intelligent Systems(Dai ruwei *et al*.,1993).In addition, studies on applying BP and IAC to the diagnosis and control of crops insects and using BP and sensor to estimate soil fertility have been conducted.

2.2 Integration with OOP(Object-Oriented programming)

OOP(E.R.Tello,1989;G.Blair *et al*.,1991;W.Kreutzer 1991)has been increasely integrated with ES, such as Object-oriented Expert System(Tian Shengfeng,1993),Object-Oriented Expert System Shell established by Agricultural University of HeBei.

2.3 ES combining with database

ES could not effectively search and use large knowledge bases. While DataBase Management System has powerful functions in Data sharing, saving, searching and inqury with low redundance. There

are three ways of their combination, including system expanding, system coupling and system integrety. EDBS aims at sharing information prcessing, where ES responses for reasoning ,while DBMS responses for sharing and protection. Plenty of studies have conducted. For instance, studies on Realization of Knowledge Expression under DBMS (Liu dongliang *et al*., 2000), Design of Dynamic Fuzzing Expert DataBase System (Li Fangzhang *et al.*,1997).

3 Progress of ES in soil and water conservation

The applications of ES in soil and water conservation began at early 1990s.With the accumulation of knowledge and experiences of soil and water conservation and the application of computer technology in soil and water conservation, the importance of expert systems has been more and more concerned. Geographic Expert System and Land Estimation Expert System in the Gully Region of Loess Plateau are both the representatives of early systems . Soil and Water Conservation Expert System developded by FuWei (Fu Wei,1994),has multi-functions including fast and accuately predicting and monitoring the process of soil erosion, and giving feasible proposals for the comprehensive management of soil and water losses as well as planning of soil and water conservation. This system uses production rules. There are some other systems such as Land Use Estination Expert Systems, Expert System for Election of Measures of Comprehensive Management in Small Watershed and the Vegetation Disposition Expert System designed for the Construction of Protecting Forests System(Lu Shouyi,1995).With the progress in softwares, languages used for expert systems developing rang from LISP, PROLOG to C,C++, VC++. The Windows 95/98 system have provided more friendly platforms for the development of expert system in soil and water conservation, which help improve the interfaces of users. The Measures Disposition Expert System of Small Watershed Comprehensive Management (He Guangming, 1997) is developed under Windows using VC++. At the same time, many researches on the integrations of ES, GIS and RS have been conducted. Geographic Expert System (Ma Ainai, 1992) is a early kind of system based on GIS. In addition, Vegetation Measure Expert System Based on GIS (Zhang Xiaoping, 1998) combines ES with GIS including database, model's base, graphbase and knowledge base. It is designed to give advice to the selection of forest species, analysis of disposition of vegetation measures and estimation of feasibility as well. There are some other systems such as Expert System of Land Estimation (Sun Lida, 1996), Soil and Water Conservation Fussy Expert System (Li Qinghe, 1999), Intelligent Planning System for Small Watershed (Wang Chunling, 1999), Expert System Used for Automotical Selection of Unit Hydrographs of River Basin (Shu Chang *et al*., 2000) and Expert System of Optimum Plan for the Mudflow Control (Chen Rui *et al*., 1999).

Therefore, expert systems of soil and water conservation may be summarized as follows: (1) expert systems of soil erosion; (2) expert systems of land use estimation; (3) expert systems of disposition of biologicl practices; (4) expert systems of soil and water conservation planning.

4 Prospects for expert systems in soil and water conservation

At present, studies on ES in soil and water conservation cover the following aspects including languages utilized for the development of ES, users' interfaces, knowledge expression, methods of reasoning as well as the integration of GIS,RS and DSS. However, there still exits deficiencies and future researches should lay a central focus on: (1) Further study on the integration of ES,GIS and DSS. The establishment of intelligent decision support management system, which taking ES as the core; (2) comprehensive utilization of knowledge expression, such as semantic net, skeleton knowledge etc., Especially suitable for the field of soil and water conservation; (3) selection on the methods of reasoning; (4) ES combing with neural networks, databases, multi-medias etc.; (5) developing expert system shell of soil and water conservation to shorten the developing period and avoid unnecessary repetition.

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