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INFORMATION TECHNOLOGY AND GEOINFORMATION DEVELOPMENT

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INTRODUCTON

Traditional approaches used for geoinformation acquisition, processing, and storage have been revolutionized over the past few decades due to rapid development in information and communication technologies. Traditionally, field data was collected in the field and processed by hand or with the assistance of a calculator and presented mainly as manually drawn maps or plans. Aerial surveys were mostly performed by analogue aerial cameras. Analogue photogrammetric plotters and mirror stereoscopes were the main operational equipment for mapping the earth's surface and the produced maps mainly presented in a paper form.

Now field data can be directly acquired in a digital format by the use of electronic field to finish equipment for angle and distance measurement and global positioning system (GPS) for accurate determination of positions thus significantly reducing time and procedures required for acquisition and preliminary processing. Although, aerial survey is still in usage, remote sensing (RS) satellites with different spatial, spectral and temporal resolutions are playing a significant role for primary spatial data acquisition. The appearance of multispectral images has greatly advanced the development of digital image processing techniques. Analogue photogrammetric plotters have been replaced by analytical plotters and visual interpretation is giving way to computer-based image analysis. Conventional paper maps are being replaced by digital databases [5].

In recent years, demands for geoinformation has greatly increased and the problems to be solved by spatial analysis have become very complex. Traditional map overlay analysis is too slow for spatial analysis and not efficient to meet current requirements. Spatial decision making has required a more integrated approach of the existing techniques and technologies. These growing demands for spatial information and analysis could only be met by the use of computer technology. To meet these demands Geographical

Information Systems (GIS) - powerful tools for spatial data integration, processing, analysis and presentation – have been developed [6].

At present, knowledge-based systems (KBS) are widely used for sciences and applications dealing with geoinformation. Different types of these systems have been, and are being developed depending upon the solution of the given problems and the structure of knowledge representation. Various attempts are being made to develop a proper KBS that can integrate data from multiple sources [3].

The aim of this report is to describe the methodological evolution carried out for geoinformation processing and presentation at the Institute of Informatics, the Mongolian Academy of Sciences (MAS). For this purpose, old and new approaches and some of the significant results have been briefly reviewed.

A FORMER APPROACH USED FOR GEOINFORMATION PROCESSING

Until 1990, most spatial analyses were carried out manually using conventional maps and analogue RS photographs. Some of the attribute data to support the spatial analyses were processed by the use of statistical packages on primary PCs. At that time the research was mainly focused on development of methodology for complex analysis of natural and anthropogenic processes in different zones of natural and climatic conditions; establishing the correlation of linear and circular geological structures with evidence of location of mineral resources; evaluation of geological patterns, underground water resources, status of pastoral vegetation and air pollution using analogue RS data.

A NEW APPROACH FOR GEOINFORMATION PROCESSING AND SPATIAL DECISION MAKING

In 1990, the Institute received a PC-based ERDAS system with all supporting peripheral devices within the framework of the UNDP project MON/88/010. Moreover, the Institute received ILWIS and Arc/Info GIS packages. The approach used for traditional spatial analyses has been totally changed. Visual interpretation of RS images has been replaced by direct interpretation on a computer screen. The results of the interpretation are stored in a digital form and further integrated with other spatial information or attribute data sets thus greatly simplifying procedures for spatial analyses. The outputs are presented in digital, map, graph and table forms and used for different decision making processes. Diverse methods for RS image processing and spatial analyses that can integrate data from multiple sources have been developed and different models for GIS design and their implementations for the test polygons have been carried out. In general, the research carried out at the Institute in the field of geoinformatics can be grouped as follows:

1. Development of GIS, spatial modeling and analyses
2. Development and application of techniques for spatial data processing and data fusion
3. Development of knowledge-based techniques to make a linkage between RS and GIS
4. Development of interpretation and processing techniques of radar images.

Some results concerning each of the groups are briefly described below.

Development of GIS, spatial modeling and analyses

In 1990 a complex airspace experiment was carried out in northern Mongolia within the framework of the International Ad hoc Project "GEOMON-90". The aim of the experiment was to develop a systematic approach for the investigation of the productivity of pastoral vegetation and ecosystem changes in a forest-steppe zone of Central Asia. To solve the problems of the study, a spatial decision support system using ERDAS and ILWIS GIS software was developed. The database was created in 3 different levels (space, air and ground) each of which has its own peculiarity. As a result of the study, the productivity of pastoral vegetation and its effectiveness in the improvement of national economy at local and regional levels was defined. Furthermore, the relationship among ground, air and space platforms was established and many new land use/land cover changes, their related natural laws and other influences were determined. For example, it was established that due to developing agricultural productions slope, water, and wind erosions have been increased and the usage of land resources is totally submitted to the existing natural laws [3,10,11].

In the meantime, a similar experiment was carried out to study the changes in a steppe ecosystem, its pasture degradation and soil erosion in south-eastern Mongolia using RS data and ground measurements. For the study, different image processing techniques and GIS analysis were applied. The results were compared with the results of the experiment performed in the forest-steppe zone in terms of the changes occurred due to natural effects or anthropogenic influences. The results indicated that the degradation process in the steppe zone is stronger than in the forest-steppe zone and this is influenced by the mechanical composition, depth of plough horizon of the soil and the strength and direction of the wind [11].

Development and application of techniques for spatial data processing and data fusion

A method to estimate prospective ore-bearing areas using multivariate statistical and image analyses was developed. In the analysis, structural information extracted from RS data sets through automatic feature extraction or visual interpretation, digital thematic maps containing classes of objects to be needed for GIS queries, and other ground truth data are integrated and assessed by the use of a factor analysis. The determined factors are mapped and isolines for each of the calculated factors are drawn. The isolines are overlapped and through the interpretation the new possible locations of the observed mineral resource are defined [12].

The origin data of Mongolian geodetic network was established. Further, it was refined using continuous GPS measurements performed for 5 years and was compared with the results of an astronomical observations for latitude and longitude carried out for 30 years. The result showed that there is a need to determine the negative anomaly of a gravitation field of the granites in the Bogd Uul mountain. For this purpose, gravimetric data was integrated with GPS measurements, and mathemaically processed. As a result, there was established that, WGS-84 system is 8 times more appropriate than a Krassovsky reference ellipsoid [9].

A new technique to detect the main ecological boundaries from RS data was developed. By this method, the histograms of the interested parts of the images are thoroughly analyzed and the lines of land surface structures are taken into account. These lines can easily be illustrated on a plane by the height differences and related x,y coordinates. To detect the main ecological structures the negatives and positives of the correlated intermediate images were used [8].

Western Mongolia is an actively deforming region of Central Asia. To study the slip rate of certain active faults a complex research using differential GPS measurements, satellite images, aerial photographs and ground sampling was carried out. The result of this study demonstrated that a Bogd fault which ruptered in 1957, has a slip-rate of 1-2mm per year.

The potential to use RS data for forest resource study was investigated. As a test site, ‘Bogd-Uul’ mountain situated in central part of Mongolia, near the Ulaanbaatar city was selected. For the analysis, multi-temporal RS (SPOT PAN, SPOT XS and Landsat TM) data and forest taxonomy maps were used. As a result of the digital image processing, GIS analysis and visual interpretation of the available RS data it was concluded that primary satellite data can be used to detect the structure of the forest formation and macro-geocomplexes, whereas RS data with enlarged scale can be used to interpret the structure of classes and groups of forest associations as well as meso and microgeocomplexes [7].

Development of knowledge-based techniques to make a linkage between RS and GIS

The Bayesian maximum likelihood classification (MLC) was modified using a knowledge-based approach. In the modification, after applying the decision rule, derived likelihood vectors are stored within a GIS. To perform the analysis a prototype KBS, linked to a GIS (ILWIS) was developed. Whilst the GIS is used to store digital satellite images or map and other data needed for the production of final land use map and data manipulation procedures, the KBS performs the actual classification process based on knowledge about conditional- and prior probabilities [1,3].

A knowledge-based approach for land evaluation using RS and GIS data sets was developed. Land evaluation requires extensive knowledge and different conditions to be fulfilled. In this study, the basic object consisted of the surface elements characterized by various attributes some of which are unknown. Those unknown attributes were determined through the processing (ie, slope calculation using contour map, land use information extraction using statistical pattern recognition) of RS and GIS data. In the analysis, the existing and extracted information were integrated and a rule-based approach was applied for final decision making [2].

Development of interpretation and processing techniques of radar images

The studies on the backscattering characteristics of different land features and soil moisture were carried out in 4 different geographical regions of Mongolia using monotemporal ERS-2 SAR PRI images. The research demonstrated that monotemporal images can be successfully used for analysis of different land cover types. To support the interpretation and analysis, different SFCC and PC images were created. The SFCC images created by the combination of different spatially and spectrally enhanced bands, and PC images, enhanced the tonal variations of different feature types and were useful for the improvement of the interpretation and analysis. As it was seen, when the PCA was performed, in the PC1 the variance of the high pass filters were dominant, while in the PC2 and PC3 the variance of enhancement filter and variance filters were mostly dominant, accordingly. However, in all cases the SFCC images performed better than the colour PC images created by the combination of the PC1, PC2 and PC3. Nevertheless, a combination of the PCs with one another enhanced band whose variance is not dominated in those PCs also created good images. Also the study demonstrated that on the basis of knowledge about the land surface and backscattering properties of natural features, it is possible to judge on the soil moisture condition in more flat areas of different geographical sites and compare them if the same replica power was used. In addition, the analysis indicated that the soil moisture changes in different geographical areas of Mongolia and it is higher in northern regions than in the southern regions [4].

CONCLUSIONS

The aim of this paper was to describe the technological and methodological changes that have occurred in geoinformation acquisition, processing and presentation at the Institute of Informatics, MAS due to rapid development in information and communication technologies. For this purpose, the approaches used before and after the acquisition of geoinformatics techniques and technologies were briefly reviewed. To demonstrate the advance made in this field some results concerning various fields were briefly highlighted.

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