

IMPROVING URBAN PLANNING BY INTEGRATED UTILIZATION OF REMOTE SENSING AND GISS

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Abstract:

In recent years, there is an increasing demand for improving the efficiency and reliability of urban planning in China, due to the inclusive changes of concepts and contents of urban planning and management. The integrated utilisation of remote sensing and GIS technology in improving urban planning was therefore approached by the author and his research group. The basic methodology of this work is to make the integrated use of the advantages of remote sensing, GIS and urban planning knowledge/ models to develop new spatial information collection techniques/ procedures and specified spatial analysis tools for supporting the formulation and implementation of urban planning. The study was conducted in three different stages (levels) of urban planning in order to examine the integrated utilization of remote sensing and GISs in the hierarchical urban planning environment. The final objective of this work is to develop a micro-computer based prototype for an Urban Planning Analysis and Management System (UPAMS).

1. INTRODUCTION

The research on the integration of remote sensing and GISs has been conducted from two perspectives. The first views the integration as a joint processing of remote sensed data and GIS data and much work has been devoted to overcoming technical obstacles to the technical integration, such as converting between vector and raster data structures, jointly displaying digital imagery and maps, and more recently unified data structures [Edwards, 1991], [Davis, et al., 1990]. It is hoped that continued developments should lead to an integrated system, capable of handling multiple data structures and supporting complex spatial analyses and user queries [Edwards, 1991]. The second is more application oriented, which aims at taking advantage of these data and making the best use of these new technologies to assist decision making in existing organisations or to investigate a real environment [Davis, et al., 1990], [Chen, and Sun, 1990].

In this paper, the research work on the integrated utilization of remote sensing and GISs in urban planning and management of the author and his research group in Wuhan Technical University of Surveying and Mapping (WTUSM) is presented in the second perspective. This work was motivated by the increasing demand for improving the efficiency and reliability of urban planning [Zhao, 1991], and the growing needs for value-added exploration and utilization of spatial data in the surveying and mapping community [Chen and McLaughlin, 1992]. On one hand, urban planning is a goal setting and policy formulation process and is based on the analysis of existing problems, and on the prediction of their evolution via simulation and implementation of alternative policy issues. Its successful formulation and implementation is contingent upon good information, effective analysis techniques and communication mechanisms [Huxhold, 1987], and its efficiency and reliability would be certainly improved if more current, accurate and reliable information and efficient analysis tools could be provided [Lam, 1990]. On the other hand, the significant development of remote sensing and GIS technology in recent years provide new opportunities for producing more spatial information and for developing new spatial analysis techniques. Therefore, remote sensing and GIS technology have been utilized by the author and his research group to develop new spatial information collection techniques/ procedures and specified spatial analysis tools for urban planning. In section 2 of this paper, the basic methodology of this study is first examined. The technical considerations for the integrated utilization of remote sensing and GIS in three different urban planning stages (levels) are presented in the third section. And lastly the future research directions are briefly given in section 4.

2. METHODOLOGY

The basic methodology of this work is developed to exploit the integrated use of remote sensing and GIS as well as urban planning knowledge and models to develop new spatial information collection techniques or procedures and specified spatial analysis tools for supporting the formulation and implementation of urban planning.

As shown in Fig. 1, in many cases multi-date and multi-scale remotely sensed data of the urban area under consideration might be obtained. This advantage offered by remote sensing facilitates the collection of some of the current and historical spatial information in different geographical regions. In fact, some spatial information may not be available and may not be collected with conventional collection techniques, such as the breached reach of a regional river, the morphological evolution of an urban system, etc., which are essential for urban planning. Instead, these spatial phenomena might be easily perceived and determined with the help of some multi-date airphotos, satellite imagery and appropriate image processing techniques. On the other hand, multi-scale remotely sensed imagery may provide good means for examining and approaching some other spatial phenomena or problems in different geographical regions, such as urban built areas, urban planning areas and larger regional areas [Chen and Qiu, 1990].

The formulation and implementation of urban planning can benefit greatly from the use of GIS technology to facilitate its spatial data management, to perform complex spatial analysis, spatial simulation and spatial query, and to visualize and output the facts, analytical results and the impacts of planning alternatives. However, the analysis functions of conventional GISs cannot meet the requirements of urban planning formulation and implementation, and a natural approach is to integrate appropriate urban planning knowledge and models and GIS tools to develop specific urban planning analysis functionalities [Chen and Qiu, 1990], [Patterson, 1990], [Taylor, 1991].

Since there exist different and hierarchical stages (levels) of urban planning, the integrated utilization of remote sensing and GISs were examined respectively for three such levels-urban general planning, landscape planning and planning management in order to meet different technical requirements and develop a unified application strategy in the hierarchical application environment.

3. CONSIDERATIONS FOR INTEGRATED APPLICATION

3.1. Urban general planning

In China, urban general planning is a comprehensive urban planning activity which deals with a variety of urban problems, such as urban systems, industrial production, circulation, environmental protection, living conditions, regional development, etc. In the cooperated projects involving provincial and municipal urban planners in Hubei province, remote sensing and GIS technology were used to collect the multi-scale spatial data and to support spatial analysis in urban general planning in several cities.

3.1.1 Collection of multi-scale spatial data Multi-scale and multi-date satellite imagery and airphotos were used, with the contribution of other available auxiliary data/documentation, in the urban general planning of Shashi city [Chen, and Qiu, 1990] to collect spatial data in the following four geographic regions:

a) regional context, eg. regional geological linear features and fault structures; geographic distribution and change of rivers and lakes; regional land form and land covers; geographic characteristics of cities and towns in the region; and dynamic hydrological phenomena, such as the breached Yangtze river.

b) urban planning area: land occupation and relevant quantities; unfavourable geological phenomena for urban construction; touristic landscape, ruins of ancient cities.

c) urban built area: urban landuse (with the first two levels of urban landuse classification); urban densities of geographic units (such as building coverage density, floor area ratio, green coverage, population density, etc.); geographic location of tall chimney, escaped waste water, solid water; change and /or expansions of urban morphology, fringe area, landuse; and the implementation rate of the last urban landuse plan and the relevant causes.

d). specified zone: more detailed landuse classification. For a middle sized city, the regional area under consideration is normally about ten thousand km² and satellite imagery are useful for collecting spatial data over such a vast area. The urban planning area is about several hundred km² and both satellite imagery and airphotos may be used there. As far as the urban built area and the specific zone are concerned, the former may be tens of km² and the latter may have less than one km², hence large scale airphotos or airborne MSS data are necessary to derive the detailed spatial data. The processing and interpretation procedures of the multi-date and multi-scale remotely sensed imagery are developed on the basis of current photogrammetry and digital image processing techniques, as shown in Fig. 2.

3.1.2 GIS-based urban general planning analysis Several spatial analysis functionalities were developed by integrating general knowledge (such as mathematical methods) and specialized urban planning knowledge and models with the GIS tool, and have been used in the urban general planning in several cities .

a) Urban land suitability evaluation.

This is approached as a multi-factor synthetic evaluation of the natural factors (such as elevation, slope and soil bearing capacity) and socio-economic factors (such as degree of urban concentration, landuse, administrative inference, traffic time-distance, accessibility of transportation, water and power supply). Some original data may be collected via remote sensing, and the GIS tool is used to generate the raster data for each factor and to support the interactive evaluation process with a fuzzy weighting method [Chen, et al., 1989].

b) Urban environmental quality assessment.

While the basic data for social environmental factors (such as population density, building density, and housing quality)

may be derived from remote sensing imagery or from other data sources, some special environmental models (such as the Gauss smoking model) and digital interpolation methods were used to generate the basic data for natural environmental factors (such as air pollution, water pollution, traffic noise) [Chen and Qiu, 1990].

c) Urban traffic analysis and simulation.

Three specialized traffic analysis functionalities were developed and GIS was used to support their data storage, data manipulation and display [Sun and Bian, 1990]. The first one is current traffic volume analysis, including O-D distribution, time variation of road segment traffic volume, traffic generation between traffic zones in different modes, ie, by bicycle, vehicle or on foot. The results are distributed on the street network in the GIS and displayed on the screen. The second is traffic forecast, including trip generation, trip distribution, mode choice, and trip assignment. The trip generated by the proposed planning alternative can be distributed over the streets and then assigned to the appropriate zone with the support of the GIS. The third functionality is for transportation optimisation, including the evaluation and adjustment of proposed road networks and of other relevant parameters.

d) Medium and long term projection or prediction of socio-economic evolution.

Different mathematic methods (such as time series analysis, multi variable regression) and specific models (such as population models) are used for medium and long term projection of socio-economic development. Furthermore, a grey-fuzzy linear programming model was also developed for the socio-economic prediction [Sun and Chen, 1992].

Currently, some other urban general planning analysis functions are under examination, including urban system analysis, urban sewerage analysis and urban flooding analysis.

3.2. Urban landscape planning

The integrated utilization of remote sensing and GIS for Chihu landscape planning in Huangshi city has recently been completed. Multi-date airphotos and DEM data were used to derive the basic spatial information needed for landscape planning, such as the characteristics and statistics of water bodies, topography and special objects in that area; the current and historical landaus, etc. The following landscape analysis methods were developed and realized on the basis of the hybrid GIS used: visibility analysis for a given point; visual field analysis for a point (selecting a suitable site for the city mark), a line (front view analysis, visual corridor analysis) and an area; simulation of landscape change due to a development site (such as a building); and some landscape based planning analysis, such as location of sighting points and selection of tour lines.

3.3. Urban planning management

One of the main tasks in urban planning management is reviewing building applications, tracking and controlling the construction projects (also called permit tracking) afterwards. It is based on the planning guidelines and regulations and on some specific objectives (such as preserving certain characteristics of the downtown area) [Lam, 1990]. Therefore, it requires a series of qualitative and quantitative analyses of various spatial and aspatial data, which are frequently time consuming and tedious. Our current research work is confined to this particular urban planning management problem, and the GIS is used to manage spatial and aspatial data and to develop specialized spatial analysis functionalities for assisting or supporting the building application reviewing and construction tracking activities.

The use of GIS for storing and managing spatial and aspatial urban planning data leads to the establishment of an urban planning GIS [Chen, et al., 1888], [Weber, 1990], [Lam,

1990], which will allow the planning staff (even for the building permit applicant) to query easily the basic information about the desired site and other relevant information (property, planned land use, building density, infrastructure provision capacity, ...) needed to process permit applications. In fact, it is done by mapping the desired project boundaries in the GIS and overlaying it with other coverages (property data, land use plan, ...). In some cases, more complex spatial analysis may be needed. For instance, some simulation should be carried out to examine the impact of the reviewed construction on the capacity of certain kinds of infrastructure, or a suitable construction site should be selected for the applicant. In addition, permit tracking can be realized with an urban GIS by examining and identifying spatially the construction project for which a permit is being issued. Therefore, the GIS-based analysis for sewerage and water supply simulation, site selection, building height and density control, spatial permit tracking are currently under examination.

3.4. Development of UPAMS

Based on the above case studies, the final objective of this work is to develop a micro-computer based prototype of an Urban Planning Analysis and Management System (UPAMS), as shown in Fig. 3.

The system consists of two application packages and a GIS tool. The first application package is the urban planning analysis package (UPA) which has the specialized spatial analysis functionalities for urban general planning, landscape planning, etc. The urban planning management package (UPM) is the second application package which provides specialized spatial analysis functionalities for urban planning management. The hybrid urban and regional GIS tool (URGT) is based on a hybrid (vector and raster) spatial database management system developed in-house and is used as a supporting tool for UPA and UPM.

4. SUMMARY

It has been shown that the integrated utilization of remote sensing and GIS could provide more spatial information and spatial analysis functionalities to support the formulation and implementation of urban planning. Currently, there is still a lot of work to do in both research and operational use. In fact, this work could be considered as the initial research efforts for spatial decision support in the urban planning case [Chen and Gold, 1992]. The future research directions include the development of an urban spatial information infrastructure and urban spatial decision support systems.

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