Towards The Modelling Of Sustainable Cities With Multi-Reactive Agents

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Biography

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Introduction

Urban planning tools often consist of a modelling framework linked with a set of indicators, by which the sustainability implications of city policies can be assessed (Leitman, 1999). A sustainable city can broadly be defined as taking action plans and policies that aim to ensure adequate resource availability for integral and long-term development (REC, 2003). Our work aims to employ multi reactive agents with a GIS for developing an “intelligent spatial decision agent” in complex urban areas and their sustainable development. Such simulation approach can provide valuable tools for planners to explore urban scenarios that result from different land use policies. This paper is intended to be a review of agent-based modelling works and their relevant to sustainable cities.

Urban Modelling

Since the late 60’s and early 70’s, a period in which the development of elaborate mathematical models for urban planning applications emerged, new scientific and technological development have considerably changed the fields of spatial modelling and urban planning (Malcolm, 2002). The elaboration of new scientific paradigms based on such phenomena as complexity, self-organization, chaos and fractals has

generally emphasized the fact that exact prediction in complex city planning is not possible (Rotmans et al., 1999). The main purpose of the models is to serve as thinking tools, to help the user learn about the nature and dynamic behaviour of the real world system and find out how it is critically bounded, rather than to make definite statements about the future state of the system modelled (Engelen et al., 1999).

For systems as complex and as dynamic as cities, performing acts of planning without having some concept of how activities, land-use, and how the spatial interactions will change as the result of the intrinsic growth potential and planning interventions seems a somewhat futile exercise (Benenson et al., 2001). Hence, it is a major shortcoming of today's GIS systems not to offer the possibility of dynamic and spatial modelling in the preparation and evaluation of urban policies. This is a view supported by many authors (Batty, 1998, Eastman et al, 1993).

Cellular Automata

Cellular Automata (CA) is a modelling technique defined on a raster space. Cell states usually represent land use or land cover, and the transition of a cell from one state to another depends on the states of the neighbourhood cells. CA have proven to be useful for dynamic modelling although studies that have attempted to include GIS have had varying success (Batty et al., 1994, 1997). Most of this research emphasised urban simulation in order to understand the urban growth and its form. However, to build models that represent more practical geographical problems, it seems that more complex CA is required and that their dynamics need to be constrained (Engelen et al, 1997). Moreover, GIS are an inherently static process, they are limited for use in dynamic modelling in both their updating of cellular data and implicit cellular nature (Ward et al., 1999). They do not include procedures for explicitly handling time, are designed to process entire arrays of data, and cannot easily address varying localized operations across the spatial grid (Gimblett, 2002).

The city is a complex system and is beyond the capability of standard CA (Jiang et al., 2002). Previous research has made clear the limitations of the CA framework (Colonna et al., 1998, Loibl et al., 2002, Ward et al., 1999). Its homogeneous cellular structure and synchronous time advancement are too rigid to easily accommodate the diversity of processes that interact of overall system (Colonna et al, 1998). Standard CA should be integrated with more states, a large neighbourhood, and more constraints with complex transition rules. More integrated technology is required for simulation modelling: the use of intelligent agents is the current best approach to model the dynamic behaviour of the land-use system (Rodrigues et al., 1998).

Agents

There is no one definition for an intelligent agent. As there are several fields of software development in which they are being used, it is very difficult to uniquely define them (Haugeneder et al., 1998). The most general definition is that of task oriented software components that have the ability to act intelligently, either independently or collectively (Rodrigues et al., 1998).

The concept of a spatial agent has been introduced as a specialisation of the agent concept that can reason over representations of space, and can understand space as either physical or non physical phenomena (Rodrigues et al., 1998). Applied to spatial

models, agents become entities evolving in space and time, within an environment composed of all the passive elements of the space (Gimblett, 2002).
The research of spatial agent and GIS has received a great attention in recent years (Rodrigues et al., 1997, Ferrand, 2000, Jiang et al., 2002, Gimblett, 2002). Most of this research focused on integrating the agent-based approach with GIS for spatial simulation and spatial decision support systems (Rodrigues et al., 1998). The most exciting research for using multi agent based modelling with GIS was developed in collaboration with the team of French National Geographical Institute. The project has addressed the limitation for using agent approach with CA for dealing with complex dynamic system, which led to the conversion of the work towards a multi reactive agents system (Ferrand, 2000, Rodrigues et al., 1998). As a result of this review, issues have been raised about the tendency of adopting CA as an agent-based modelling technique.
In fact, a multi reactive agent system can be used either for simulating complex systems or for solving spatial problems (Ferrand, 2000). The use of multi-reactive agent system is a return to natural modelling, because all is needed is a simple description of objects and processes (Ferrand, 2000). The system can be integrated with any type of information such as rules or functions, and is entirely open as it is possible to add agents of any type (Wooldridge et al., 1995).
The key message of this paper is that multi-reactive agents can be adopted and is well-placed as a modelling technique to address the challenges of the dynamic behaviour of cities and their sustainable land use.

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