A Framework for Agent-Based Simulation in Tourism Planning

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Abstract. Recently, the interest of using agent-based model combined with GIS to perform simulations that seek solutions to problems in the study of tourism services and planning is expanding. However, few scientific studies or systematic methodologies in tourism research have been conducted to support the design and development of such simulations. This research intends to develop a general framework for agent-based simulations in tourism and present its possibility in practical tourism planning process. By developing an agent-based simulation combined with GIS under the protocol, planning supports to tourism bureaus and policy makers to help them assess different tourism policy scenarios and improve tourism services.

Keywords: Tourism services, planning support architecture, agent-based simulation, GIS.

1 Introduction

Recently, the methodology and technique of Agent-Based Simulation (ABS) is applied to increasingly greater number of fields (Drogoul at el., 2005). In tourism, which has become one of the largest industries in many countries (Clancy,1999) and marked by its complex nature, ABS has gained its significance as providing support for the inter-disciplined research in this field (Batty, 2005). As tourism service involves the activities performed by tourists, host communities and the whole industries involved in generating the travel experience (Moutinho, 1987), ABS can be combined with Geographic Information System (GIS) to analyze the spatial-temporal tourism interactions and activities at the macroscopic or microscopic scales.

However, the lack of general principles guiding the design and development of ABS for tourism planning has jeopardized the further integration of the different discipline and approach to cope with the complex nature of tourism services. Agent-based participatory simulation is an approach developed from the integration of Multi Agent Simulation (MAS) and Role-playing Games (RPG) (Guyot and Honiden, 2006) In ecology and resource management research, the joint-use of agent-based model and participatory experiments has been developed through years to deepen modeler's understanding of the interaction between actors involved and to assist decision-making (Bonsquet et al., 1998).

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Pattern-Oriented Modeling (POM) is an approach proposed by researchers in ecology to describe the real-world complex systems and design agent-based models accordingly (Janssen et al., 2009). With the ultimate goal to overcome the challenges of covering the complexity and eliciting the uncertainty of the system (Grimm et al., 2005), POM approach is used to explore the internal mechanism of the system (Heckbert et al., 2010).We believe that these methodologies can be applied to tourism and provide a scientific strategy for agent-based simulation in tourism planning.

This research intends to present a framework for ABS combined with GIS in the context of tourism service. By integrating POM into the framework, a strategic approach is expected to be proposed to develop ABS for tourism with more reliability. An application example of the framework in the practical developing process of ABS in tourism will be used to illustrate the potential that the framework facilitates researchers and decision makers assessing different tourism policy scenarios.

2 The ABS Framework

In ecology research, Pattern-Oriented Modeling has been used to describe the multi-level human-ecological systems with extracted indicators from observed patterns (Grimm, V., U. Berger, et al., 2006). These indicators are directly related to different spatial and temporal levels to characterize the system inclusively. For tourism, we set up the following steps (Fig.1):

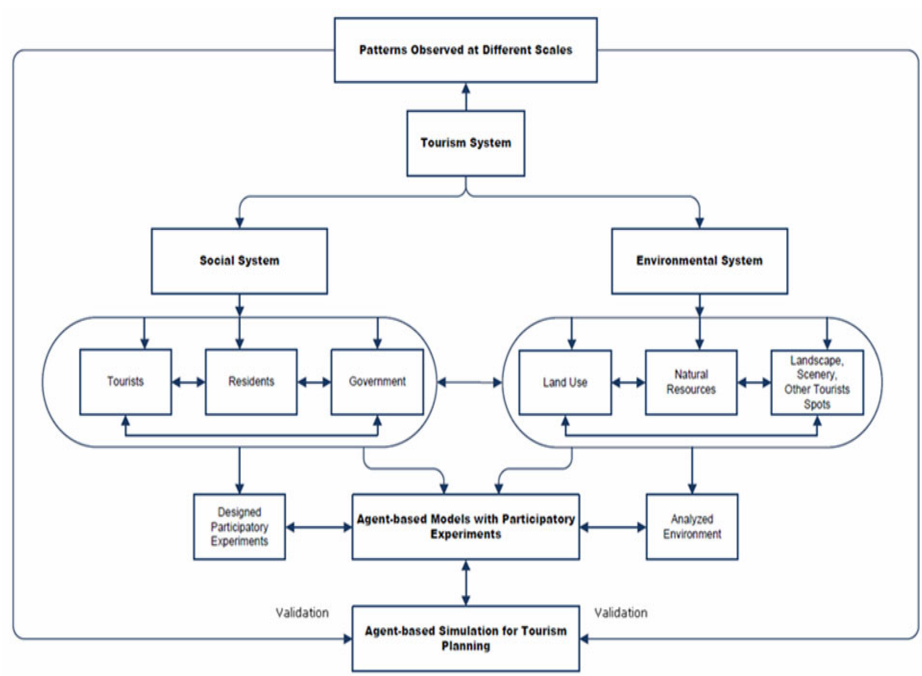

Fig. 1. The Framework

1. Describe the characteristics of tourism systems by observed patterns, set-up sub systems and a spatial-temporal matrix with appropriate spatial and temporal scales for these patterns.
2. Match the indicators of the sub systems which may have great influence on the internal interactions and those emerging patterns at macroscopic or microscopic level onto the spatial-temporal matrix accordingly.
3. Establish hypothesis, models, simulation environments based on the indicators.
4. Develop Agent-based Simulation based on the parameter and proposed internal dynamics perform participatory experiments to replace some of the artificial agents. If ABS is combined with GIS, parameters can be linked to the specific layer containing corresponding data processed in GIS
5. Perform simulation and compare simulated results to the observed pattern to modify the present model or choose an alternative model.

3 Application Sample : An Agent-Based Simulation for Tourisn Planning

3.1 Overview

Our SimHakone model (Chao, D., Furuta, K., and Kannon, T., 2010) for tourism planning in Hakone area is based on some works using agent-based models to study land use-land use change (Parker, et al., 2002; Batty, 2005; Li and Liu, 2008) with modifications regarding the differences between the characteristics of urban development system and tourism system.

The procure of developing the system follows the proposed frame work will be described in the following chapters.

3.2 Spacial and Temporal Scales Setup

Tourism plannning invovles planning activities at various hirechical levels (The World Commission on Environment and Development Publication, 1994) so that apporpriate spacial and temporal scales need to be defined. The following table includes the possible spatial and temporal scales of the observed patterns.

Table 1

Spatial Scales	**Temporal Scales**
Attractions	Hours
Tourism Services Districts	Days
	Weeks
Regions	Months

Table 1. (*Continued*)

Countries	Seasons
Global	Years
	Decades
	Centuries

3.3 Definition of Patterns and Variables

In order to describe the behavior of a tourism system and to develop agent-based models, appropriate indicators must be extracted from the emerging patterns, which can generally be divided into four groups: economic, environmental, social, and multi-dimensional. The indictors were re-projected also according to their temporal and spatial scales into the matrix as shown in Figure 2 (Adapted from Becker, 1999).

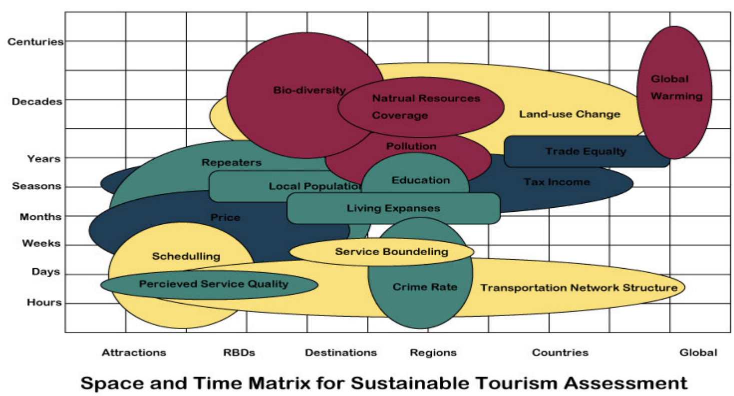

Fig. 2. Sustainable Tourism Indicators (Adapted from Becker, 1999)

3.4 GIS Layers

Spatial and statistical data can be processed using GIS and distributed into several layers of the model to represent the charateristics of the complex system that the agents share and interact with. Essentially, there are the following layers: Land Type Layer, Transportation Layer, Tourist Spot and Public Facility Layer, and Tourists and Residents Layer. Reprojection on to a ABS platform is ususally needed for future simulation. Figure.3 illustrate an example of using ArcGIS (ESRI) as the GIS to process data and Netlogo (Wilensky, U. 1999) as the simulation platform.

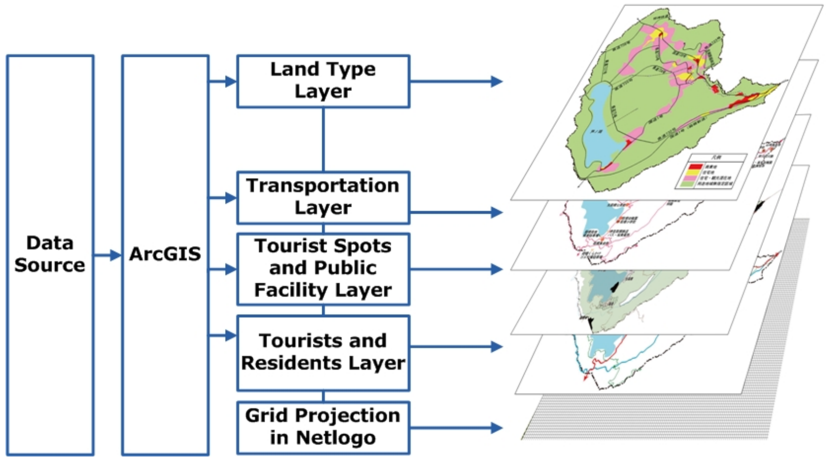

Fig. 3. Simulation Structure

3.5 SimHakone Interface

The interface of SimHakone consists of the following parts (Figure):
Main Control: Setup the original map and On/Off control
Scenario Picker: Choose one of the development scenarios for simulation
Variables Set-up: Can adjust different variables for simulation
Output Control: Report the results data to a .csv file
Viewer: View the process of the simulation
Plot: Plot the result data

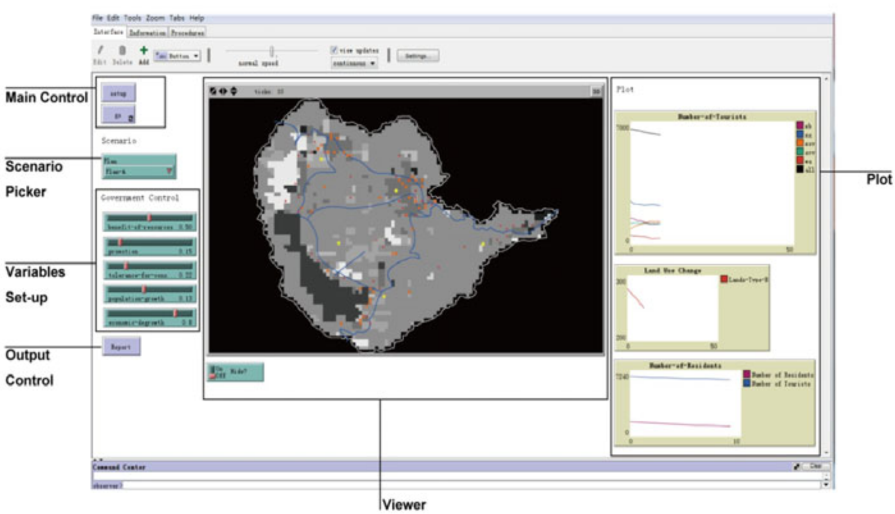

Fig. 4. Interface

3.6 Simulation and Results

A case study of test simulation was performed to demonstrate the usefulness of the proposed ABS for sustainable tourism development planning. Simulation scenarios Both the macroscopic and the microscopic level model are include in the simulation

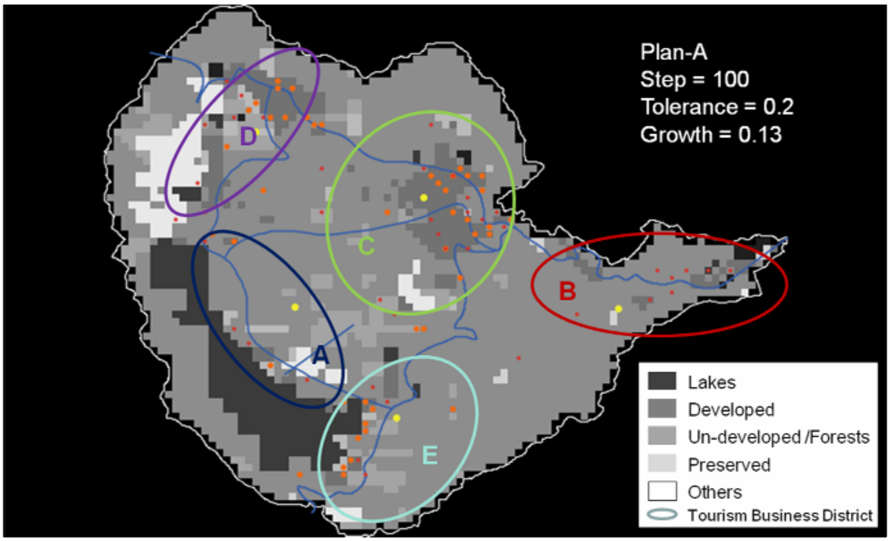

Fig. 5. Simulation Case Study

Fig. 6. Number of agents resulted from Plan A

for examining the planning scenarios. The indicators discussed in the previous chapter are included for assessing the consequences of the planning.

We divided the study area into 5 major RDBs (marked with A, B, C, D, E in Fig.5) to observe the change in land use and number of tourists in each district. It is revealed in the Simulation that the changes in government promotion (increase of the ratio of tourists to residents) which results in changes in tourists flow among different RBDs will largely influence their development pattern. FIGURE 6 shows the simulated result of land use change after taking one of the plans. The changes in land use and numbers of tourists can be reflected by the simulation and provide decision supports to the government.

4 Conclusion

Systematic methodology is needed for rational planning and sustainable development of tourism services, but the human-environmental system is complex and requires combination of studies in various disciplines. Agent-based modeling offers an approach to integrate interdisciplinary studies and simulate the complex processes for facilitating tourism services planning. This article presented a framework for designing and developing ABS for tourism planning. Variables are coupled with specific special-temporal scales to indentify patterns at both macroscopic and microscopic level. We confronted the challenge of the complex nature of tourism services by designing the simulation model under the framework. The sample ABS simulation developed under the framework demonstrated the potential that ABS can be applied into the practical planning and policy making process for Tourism Bureaus.

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