

MASOOR: The Power to Know – A Story About the Development of an Intelligent and Flexible Monitoring Instrument

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Introduction

Dutch managers of nature areas follow the policy of open nature areas (Ministerie van LNV 2005). In this way they allow people to experience, benefit from and develop an interest in wildlife and geology. This will benefit people's health and allow visitors to experience other valued aspects of visiting the countryside such as tranquillity, open space, fresh air, unpolluted waters and scenery. The last decades the managers are confronted with an increasing amount of visitors. The policy of open nature areas for recreation can conflict with the policy of protecting species in these areas. Decision makers and managers need tools to plan and manage lands to accommodate increasing human use while at the same time, maintaining the ecological integrity of the landscape (Gimblett 2005). The tool should be able to analyze and evaluate biodiversity and recreation integratively (Pouwels et al. 2006). In this paper we focus on the recreation modelling as part of this tool. More specifically, we describe the MASOOR model, an intelligent and flexible model that has been developed for front country situations.

Recreation models: the need for an intelligent and flexible model

In general, a recreation model should:

1. analyze and integrate monitoring data
2. evaluate future plans
3. transfer model results to different spatial scales
4. be flexible to different sites

5. be able to use local knowledge and data

6. be meaningful for stakeholders

Simulation models such as RBSim 2 (Itami et al. 2000, Lawson et al. 2002), Wilderness area Simulation Model (Wagtendonk 2004), Extend (Lawson et al. 2003) and GCRTSim (Roberts et al. 2002) have been developed, specifically to establish the optimum level of use of a wilderness area with regard to crowding. These models have been applied to back country areas in Australia and USA that have an extensive or moderate path density. As a result, they often use 'typical travel itineraries' (Arrowsmith & Chhetri 2003). However, in urban societies like the Netherlands, nature areas have a large recreational accessibility and a high path density. Although some visitors will follow 'typical trips', a large percentage will choose their route on other aspects like landscape characteristics (vegetation, diversity), path characteristics, and crowding (Hull & Stewart 1995, Tahvanainen et al. 2001). This raised the need for an intelligent and flexible model in which agents are able to make a lot of choices (Elands & Marwijk 2005).

Spatial-agent based models linked directly to geographical information systems hold great promise for studying complex systems such a wildlife population dynamics, human behaviour, traffic flows and other phenomena (Gimblett 2005, Itami & Zanon 2003). We explored several types of simulations in ecological applications in population dynamics and dispersion models (Verboom 1996; Vos et al. 2002) before developing a recreational model. Pedestrian movement models have been

developed since the 1970s. Recent developments in modelling techniques, and especially advances in agent based simulation, artificial intelligence and robotics, open up the possibility of developing integrated and complex models.

MASOOR

The MASOOR (Multi-Agent Simulation Of Outdoor Recreation) model is an agent-based model that focuses on the simulation of the behavioural aspects of recreational movement in natural areas.

In the model, we adopt a holistic, agent based approach to the individual movement of recreational users. An agent is an identifiable object in the computer's memory, which is autonomous, and goal-directed (Hayes 1999). Agents are autonomous in that they are capable of effective independent action, and their activity is directed towards the achievement of a defined task or goal. In our case the agent is spatially located and aware of its location. The main task for our agents is to navigate through a network of paths and to achieve one or more recreational goals (such as visiting a certain attraction, or walking for 2 hours).

The navigational implementation of the agents is adopted from artificial intelligence robotics, in the form of a Nested Hierarchical Controller. This allows us to build a modular framework that simulates behaviour on different geographical scales. The framework consists of a movement control module and a 'world model' (see figure 1). The world model is spatially explicit and directly linked to a GIS.

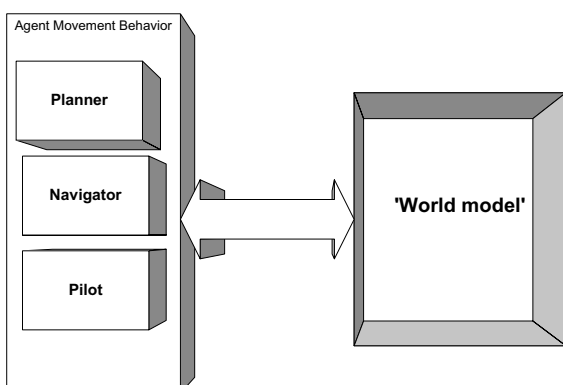


Figure 1: The framework of MASOOR.

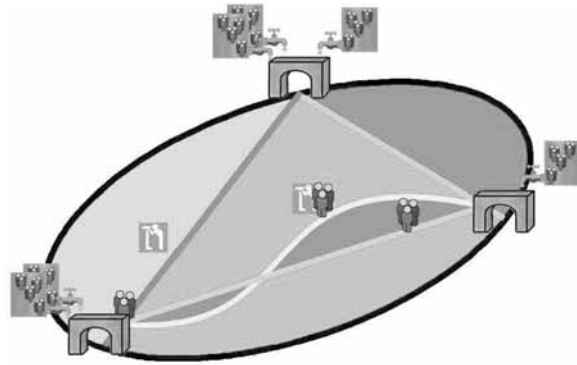


Figure 2: Graphic representation of a network.

The world model

We treat the environment or natural area as a fixed and closed system with a limited number of fixed entry points. Typical gates are car parks, village centres and railway stations. These gates are projected on the nodes of a track network. Recreational agents are arriving in the modelled area at the gates. Each gate can contain one or more sources that release the different agent types, with their own arrival distributions, simultaneously into the simulation (see figure 2).

The individual tracks in the network are used by the agents to 'walk' along, and are attributed for their surface type, attraction and other characteristics. These attributes make it possible to select paths that specific types of agents prefer. In some phases agents choose an attraction as a distant goal. These attractions can be presented as the nodes of the network, like a pub or tea room, or in the form of a grid, representing an attractive area.

Agent movement behaviour

The logic of the movement control module is based on a Hierarchical control system commonly used in robotics and intelligent agents (e.g. Kronreif & Furst 2001). This system is divided in three sub modules: planner-navigator-pilot.

1. The planner in MASOOR selects attractions and other global goals to achieve. It also keeps track of the time spent, and will change the phase¹ if required.

¹ The modular framework provides a flexible way to implement different types of agents. The simplest implementations use three phases in the agent's visit to the recreational area. In the first phase the agent is entering the area and leaving the entrance. In the second phase the agent has a more exploratory behavioral characteristics, it is browsing around in the more attractive areas. In the last phase the agents is making its way back to the entrance.

2. The navigator converts the results of planning to an increased level of resolution by adding additional information and setting the limits for the pilot.

3. The pilot implements the results of navigation and transforms the abstract commands of the navigator into actual movement selections. The navigator leaves a number of alternatives for the pilot. The pilot is able to make a choice between the different alternatives by using a composite of simple rules. The results of those rules are evaluated by using multiple criteria analysis and by applying a fuzzy selection algorithm.

Each of these systems is operating on its own geographical scale. In the dynamic operation of the model, agents use the three levels of behaviour to navigate and find their way around the network. We assume one or more phases in the agent's visit. In each of those phases the goals and behaviour are adjusted.

Applications and future developments

MASOOR is still being in development. The application of MASOOR in a number of case studies:

- Wadden Sea Area (2003)
Pilot study, goal: development of behavioural rules
- Veluwe (Grobben 2004)
Pilot study, goal: stakeholder acceptance
- Dwingelderveld (Elands et al. 2005)
Academic study, goal: developing parameters recreation and nature quality
- PROGRESS (Henkens et al. 2006)
Implementation study in New Forest and Fontainebleau, goal: planning, future scenarios and visitor management.

Future developments of MASOOR include:

- Calibration of the model using GPS data
- Establishing links to regional and national scale models such as FORVISITS (Henkens et al. 2005)
- Developing rules of thumb for national models

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