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The Assessment of Constrained Markov Chain Models and Multi Agent Based Models for Adequately Representing the Development Process of Settlement Areas in a Central European Region

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Extended Abstract

Modelling land cover and land use development processes is a very complex task especially in Middle European Regions, where the topographical, historical, political and social structures and driving forces influence the development in a very unpredictable way. So the modelling approaches have to consider many different aspects and represent them in an appropriate way. In this study the representational force of two approaches for modelling the spatial development process of settlement areas in Central Carinthia (Southern Austria, Europe) represented by some land cover classes (settlement, industrial, traffic etc.) delineated from historical and recent satellite data are compared.

The objectives of the study are

- (1) to describe the two representations of the change process using a conceptual framework,
- (2) to analyse the (empirical) deficiencies of each modelling approach and to advice improvements,
- (3) to identify further error sources concerning data, class semantics or the modelling concepts and
- (4) to advice the design of an integrated “land use change simulation approach” combining the advantages of the single models.

The first model is an extended version of the “Constrained Markov Chain Modelling Approach” realized by the IDRISI Kilimanjaro Modul “CA_MARKOV”, extended by some additional components using the Macro Modeller of IDRISI. The second model is a multi-agent based model programmed using the freeware program “StarLogo” (<http://education.mit.edu/starlogo/>).

The “Constrained Markov Chain Modelling Approach” uses a transition probability matrix for changing one cell class value into another, a transition suitability image for each landcover class, which represents the suitability of a cell to change its value from one class value to another and a cellular automata procedure which provides spatial consistency of areas having changed their class values.

Procedures for the treatment of spatial objects (cell groups representing one spatial object), for considering spatial constraints and new development areas, for including coincidences and some other events were added. Nevertheless the approach is a top down one, which represents a process driven by global rules and local constraints.

The “Multi-Agent based Approach” is a bottom up one, which defines settlers as agents, acting individually according to laws and rules. We tried to include the same process features as the Markov model can handle (e.g. spatial object size, spatial consistency). But the modelling approach provides additional features like the consideration of various types of settlers having different preferences, neighbourhood preferences and communication between the settlers.

Each approach has different deficiencies. Common problems are

- the demand for “spatial objects” instead of raster cells as basic elements of the spatial development process,
- the consideration of discontinuities of settlement sprawling to start new settlement clusters,
- the consideration of sudden or coincidental events and the spatial representation of political decisions.



Fig. 1: Results of the “Constrained Markov Chain Modelling Approach”, left year 2000, right year 2010. Main effect: enlargement of the red regions, which represent the settled areas.

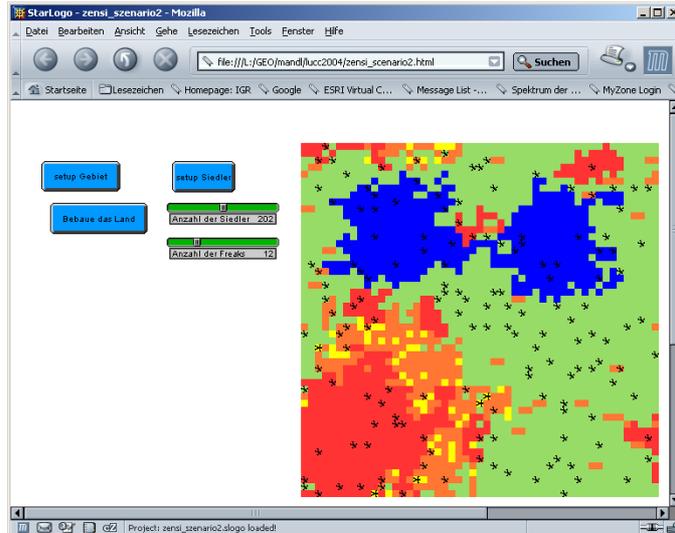


Fig. 2: Results of the “Multi-Agent based Approach”, result of one simulation run. Main effect: Controlled enlargement of the settlement areas, representing two different types of settlers.

One study area was simulated using the two approaches and the results were compared. For this spatial crosstabulation, spatial metrics and statistics were used, because only the structural similarities are important and can be compared.

The work shows that conventional (top-down) models of the settlement land use change process in Middle European regions do not represent the real process in a sufficient way, because the process has too many individual (parcel or actor referred) based components. This can be done by multi agent based approaches, but these consist other components (decision modelling, consideration of spatial data and secondary conditions) which have to be developed and adopted to the special modelling problem. So a combined modelling approach is proposed and designed in the conclusions.