Virtual Leodium: From an historical 3D city scale model to an archaeological information system

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Abstract

Since 1907, the University of Liège houses, among its Art Collection, a scale model representing the city of Liège in the 1730s. Due to the conservation and preservation conditions, the access to this masterpiece has long been restricted. In 2009, the Virtual Leodium Project set up to promote access to a larger public and assuring the conservation of the scale model. A 3D scan of the scale model was the starting point of the interdisciplinary project gathering competence of geomatics, archaeology and physics. The main aim of the project is to develop an urban archaeological information system. The development of an archaeological information system responds to the increasing demands from archaeologists and historians for a powerful set of tools to manage, archive and explore large archaeological data sets in order to yield new elements, which could respond to archaeological problems.

The scale model has been scanned using an optical inspection technique producing a 3D point cloud. The cloud has been transformed into surfaces. Based on this, the reconstruction of the 3D object was performed with the 3D graphics software using the digital surface model and pictures of every building face of the scale model. The images have been rectified used as draping textures. Currently, about 20% of the entire model has been modelled in 3D.

Then, an ad hoc archaeological information system has been designed. It gathers historical information from several sources and combines them with urban geographical objects (following as much as possible international geographical standards). The prototype is developed in Java and relies on ArcGIS Engine10 which provides database capabilities as well as 3D visualization tools via the ArcScene API. Spatial and sematic data are stored in an ArcGIS Geodatabse. The virtual information system is based on a client-server architecture. The system allows visualization and navigation in a 3D virtual world.

In the long term the Virtual Leodium project aims to develop an archaeological information system dedicated to urban archaeology. Although the proposed data model is still in development, we identified several modelling ways providing a useful framework for archaeological modelling. The next research step will be to get out proprietary software and to implement our model directly in the open-source graph database Neo4j.

5th Belgian Geographical Days, Louvain-la-Neuve May 24, 2013

(Dis)connected Cities: Change in the World City Network, 2000-12

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This paper presents an overview of the shifting geographies of connectivity in the world city network (WCN). Connectivity in the WCN is measured through an application of the interlocking network model for cities. This model has been devised in the context of the Globalization and World Cities (GaWC) research network, and specifies a means of guesstimating flows of capital, people, ideas,… between cities as generated by multi-locational producer service firms facilitating the contemporary globalization of economic processes. The model is operationalized by mapping the worldwide presence of leading producer service firms. The latest data gathering, carried out in 2012/2013, provides information on the (relative importance) of the presence of 175 producer services firms across 526 cities. Firms are chosen based on their position in sector-specific rankings, i.e. 75 financial services firms, 25 law firms, 25 accountancy firms, 25 management consultancies and 25 advertising agencies. Applying the model to these data yields measures of cities' 'global network connectivity' (GNC). The empirical results presented in this paper focus on how cities' current levels of GNC compare to their GNC in 2000. At the most general level, our analysis of change between 2000 and 2012/2013 points to the continued dominance of London and New York in the face of the overall connectivity growth of Pacific Asian cities (especially Shanghai, Beijing, and Seoul).

Keywords

World City Network, Global Network Connectivity, GaWC, APS firms

Renovating Urban Systems theory

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Research on urban regions builds, often unacknowledged, on an academic legacy of urban systems analysis that flourished from the 1960s throughout the 1980s but has roots in the foundational works of economic geography. Spatially informed logics, based on the analysis of socio-spatial systems such as growth pole theory, central place analysis and the theory of cumulative causation featured prominently in that literature. However, eighty years of theorizing by different authors has evolved urban systems theory into a field full of misconceptions, incompatibilities and incommensurable theory blurring its utility to understand contemporary urban systems. Instead of jettisoning urban systems theory in favor of a unified 'network' theory as is often proposed in the literature, this paper makes a case for renovating it instead. We argue that focusing on the interactions between a system of central places, a daily urban system, and a system of global production networks can provide important insights to understand contemporary urban decentralization, metropolitanization and growth.

Keywords: urban systems theory, economic geography, urban geography

Network-based time-distance computations for an Activity-based Cellular Automata (ACA) land-use model for Flanders

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Cellular automata (CA) models are increasingly applied for simulating land-use change in urban areas. However, in areas with strongly mixed land uses, like Flanders, different types and intensities of human activity occur within a single dominant land use. This is in conflict with the discrete and dominant land-use states applied in CA. The direct modelling of the intensity of activities (population density and employment in different sectors) within a CA grid environment is an interesting alternative to model mixed and multifunctional land use.

In this research, an activity-based cellular automata (ACA) model, developed by White *et al.* (2012), is further enhanced, applied and calibrated for Flanders. It also uses a variable grid approach: linking with a regional model is not necessary because the neighbourhood is expanded to the entire modelling area. The model should be able to cope with the complex multi-nodal structure and messy morphology of Flanders, typified as it is by multifunctional land use and diffuse, fragmented urban development strung out along roads.

This presentation will explain a method we developed to compute and store distances between cells in the variable grid ACA. This calculation should be based on the existing transportation network rather than on simple Euclidian distances applied in classical local CA neighbourhoods, because the distances in the expanded variable grid neighbourhood are much larger than in the original local one. Initially we only used the road network for time computations between cells. For the final model, we are developing different accessibility calculations for different activities, including public transport and waterways.

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Policy Evaluations by Land Use and Transport Interactions Models: Does Size Matters?

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Abstract

This paper aims to study the sensitivity of Land Use and Transport Interactions models (LUTI) to the size of the Basic Spatial Units (BSU) used in that model. Even if the size BSU is often constrained by data availability, this *scale effect* (which is part of the well-known Modifiable Areal Unit Problem, or MAUP) on LUTI models has, until now, received very few attentions. Hence, objectives of this paper are twofold. First, assess the influence of the size of the Basic Spatial Units (BSU) on the simulations results of a LUTI model. Secondly, LUTI models are often used as decision tools by Metropolitan Planning Organizations. It is then necessary to study if policy evaluations based on such models is sensitive to the size of the BSU used. We focus here on evaluation of transport infrastructure improvements. The goal of this work can be expressed by the following research question: How does the size of the BSU influence the evaluation of the effects of transport infrastructure improvements made by a LUTI model?

For that purpose, a land use model (UrbanSim) is coupled to a transport model (MATsim). A simple, small scale, synthetic city is used as case study. The methodology consists in simulating the evolution of the synthetic city for three different (nested) Basic Spatial Units. Simulations results are then compared to identify the magnitude and spatial pattern of the variations induced by a change of the size of the BSU. Moreover, for each BSU, a business as usual scenario is compared to two scenarios implementing an improvement of the transportation network (a radial highway network from the CBD to the countryside) and to a public transport scenario.

Results show that the effects of a change of the aggregation level on the predicted situation (in terms of number of households or jobs at the end of the simulation in a given zone) at the end of the simulation period can be of the same magnitude that those induced by transport infrastructure improvements. Output of a LUTI models seems thus to be influenced by the size of the BSU used in the model, for both of the land use and transport components of the model. Further works will attempt to the application of the same methodology on a real world case study (Brussels, Belgium).

Keywords
LUTI models, Modifiable Areal Unit Problem

On the impacts of transport policies and urban form on traffic-induced air pollution – a modelling system

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Urban form, transport and air quality

Despite vast technological improvements and various political control strategies, air pollution is a major concern in urban areas worldwide. It is not only a hazard to the environment but also on human health. Yearly, approximately 1.3 million people worldwide die prematurely due to outdoor air pollution (WHO, 2011). Hereby, traffic is acknowledged to be the major source.

Several studies provide evidence for the influence of traffic volume, trip distribution, travel behaviour, congestion and many other aspects of transport on air pollution (e.g. Briggs et al., 2008). Linked to these aspects, is however, also the form of an urban area. It primarily impacts on the mentioned factors but further affects traffic-induced air pollution as so far investigated by few researchers (e.g. Borrego et al., 2006 or Martins, 2012).

Many argue that a compact city is the desirable urban form in the context of sustainability due to shorter travelling distances and reduced conversion of land, just in contrast to the trend towards urban sprawl (e.g. Stone et al., 2007). However, if energy consumption (Newman & Kenworthy, 2000) and total emissions (Cervero, 2000) can be shown to be reduced with more compact urban forms via reduced car use at regional scale, compactness is still debated (Gordon & Richardson, 1997). If considering not only the environmental pillar of sustainability in terms of total emissions but also the social one comprising human exposure and social well-being, the argumentation might change. The question we ask is whether selected common transport policies are efficient solutions to overcome the environmental and social challenge?

Methods

In order to investigate this question, we developed a modelling system. Choosing a purely theoretical approach is complementary to existing applied research but provides more general insights independent from spatial and context heterogeneity. This system comprising five spatio-dynamic models allows us to a) model the growth of an urban area, b) model the traffic flow which would be generated by residents commuting on the resulting road network according to a modal split based on population density, c) estimate the emissions generated, d) model how these emissions are dispersed by wind and finally e) estimate the average exposure residents are faced with at each residential location.

In more detail, the different models imply the following: The urban growth model S-GHOST is a micro-economic cellular automata approach which models the allocation of residents and the creation of a road network (following residential demand) (Caruso et al., 2010). Commuting costs and green space amenities are considered within residential choice and impacting on city shape. Next a period of residents commuting by car to the CBD on the emerging road network (monocentric city) is simulated. We calculate traffic flows based on the distribution of residential locations. Based on population density, we assume a modal split but still only consider private vehicle commutes and no congestion. Next, emissions in each location are calculated based on average speed, trip distance and distinguishing between cold or hot engine modes. Directly after being emitted on the road network, emissions are dispersed through wind. We model this by modifying a cellular-automata model developed by Marin et al., (2000) and combining it with the Gaussian dispersion approach (Abdel-Rahman, 2008). Finally, the average exposure in each residential location is calculated.

Previous models developed by e.g. Borrego et al., (2006) or De Ridder et al., (2008) analysed the link between urban form and air quality but what our model adds is the fact that changes in travel behaviour (affecting modal substitution) or other transport characteristics can be adapted easily and tested for their impact on the whole process. Thus, it permits to model the impacts of different transport policies, either on the urban structure itself or on traffic flows and respectively on air quality.

Therefore, we chose two transport policies: a) a transport tax which globally raises the price for commuting and thus, gives residents the intention to prefer locations at shorter distances to the CBD, leading to more compact structures; thus, a transport policy with effects on locational choice, and b) a policy which increases the provision of public transport based on density and thus aims at substituting private vehicles by public transportation; hence, a transport policy with effects on modal split.

Findings

We found that a global transport tax compacts urban structures. Therefore, it reduces total emissions (carbon monoxide) but at the same time adds to population exposure to pollutants. Thereby, it also reduces social well-being of residents if they have preferences for green space which they partly trade for having money for other goods than housing and transport. Contrariwise, emissions are reduced due to fewer kilometres driven. Further, residents are unequally exposed depending on how far away they live from the CBD, with residents living closest being most affected. The dilemma of either striving after a policy which aims at emission or exposure reduction or a trade-off between both becomes apparent.

Providing more public transport based on density reduces emissions as fewer residents commute by car and assimilates exposure across distances. However, the share of residents living further from the CBD cause the rest to cope with increased exposure (De Ridder et al., 2008). In comparison to a transport tax which affects structures directly, a change in modal split shows to be socially more efficient.

Most of all, we developed a model system and show that urban form impacts traffic and air quality. Apparently, if there were no change in travel behaviour despite increased compactness, the variation in exposure is much more important compared to emissions. Therefore, we conclude that a compact city alone should not be sought after if not accompanied by a transport policy.

Keywords: transport policies, urban form, air quality

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