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Urban Models:

The Decline of Theory, The Rise of Big Data and the Fragmentation of Applications

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Themes

- Defining Urban Models: A Generic Type
- Theory, Data, Models, Policy Applications
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- Cellular Automata and Agent Based Models
- The New Short Termism: The Fragmentation of Applications and the New Plurality of Planning
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Defining Urban Models: A Generic Type

These are computer models that explain and predict urban outcome such as land uses and activities therein

They are built on mathematical structures in the broadest sense of the word that range from formal and analytical equation systems to rule-based logics

They are applicable at urban scales from the metro-region to the local district level but rarely outside these scales

They either predict spatial outcomes at a cross section in time or outcomes that change in time: these types are called static or dynamic





We can write their structure as a generic type and the basic equation is called a reaction-diffusion equation. It can be written as follows



We can derive any urban model we like from this generic structure by suppressing space, time, reaction, diffusion, & external effects – & we will show how below





Urban models depend on two kinds of theory –

first *a theory of the city* which is absolutely key to the formulation of the model, and

second a theory of how the model might be used which in essence is not a theory of the city but *a theory of planning*

Urban models that began almost as soon as computers moved out the scientific lab – perhaps even in the lab in the early 1950s – were in fact articulated not for scientific purposes *per se* but for policy applications

The first example was the Chicago Area Transportation Study (CATS) which began in the mid 1950s





Urban models also depend on a generic theory of the system which is not a substantive theory but a methodology – an articulation of how a system works

During the course of the history of urban models, this has changed from a top down systems approach to a bottom up approach based on complexity. In short the systems approach treated the city more like *a machine* while complexity treats the city more as an *evolving organism*

The last feature we need to note is that urban models are appeal to positivism in the sense that we usually wish to validate them against data so that we can be sure they work in some sense – i.e. replicate the present or the past so we can use them to predict the future.





Theory, Data, Models, Policy Applications

In fact, all of these assumptions have been questioned during the last 50 - 60 years and we now need to make this history explicit. We will divide our history into four streams – implying how urban models have grappled with *theory* (of cities), *data*, *methodology* and *applications* (in planning)









The Decline of Theory and the Rise of Data, and Refocusing on Smart Cities



A gradual loosening of theory, a gradual abandonment of comprehensiveness, a much more pragmatic approach to applications, and a concentration on data. GIS is part of this, so is the idea of the smart city, of data everywhere, accessible anytime, anywhere







A major paradigm shift is now occurring in which our theory of the city in so far as there is one is under intense scrutiny.

The focus is now on much more routine localised change, on short term, diurnal change not long term change – there are many reasons for this but before I sketch these I need to return to LUTI and CA models and sketch their evolution





Land Use Transportation Models: LUTI

Essentially these are closest to the standard theory of cities which was developed until the mid to late 20th century as a model of urban economic structure and transportation based on the monocentric and quasi polycentric city

This theory has been found wanting but it is still the edifice on which a more relevant theory might be built as developed for example by Fujita, Krugman and Venables amongst others.

Let us show quickly where it comes from and what models have been built



















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reaction diffusion external effect/input $A_{i \not k+1} = \bigotimes_{it} + \beta \sum_{j \in Z_I} A_{j \not k} + (1 - \alpha - \beta) X_{it}$















If I have time I will run this model to show you are far we have come since 1964 – it is on the desktop but we have a web based version too as most software is now delivered this way



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Cellular Automata and Agent Based Models

The big difference as I will elaborate in more detail in my paper with Paul Torrens and David O'Sullivan on Saturday I think, is that these CA type models are much less rich in urban theory but essentially dynamic and built from the bottom up

Generically we can see this difference from the reactiondiffusion equation

reaction diffusion external effect/input

$$A_{it+1} = \mathcal{A}_{it} + \beta \sum_{j \in Z_I} A_{jt} + (1 - \mathcal{A}_{it}) X_{it}$$



Almost as soon as LUTI models were developed, cellular development models appeared on the scene. In 1960, Chapin and Weiss began their work on the development process.

Alan Schmidt built an urban development animation as a precursor to raster based in GIS in 1967 and it is so good it is worth showing

It takes data from the early 19th century on land parcels and prints SYMAP type maps of this at each time stage and then strings them together and uses a movie camera, I guess, to develop the animation as follows:











CA models in fact are based on

- a grid of cells,
- a <u>neighbourhood</u> around each cell which is composed of the nearest cells,
- and some <u>rules</u> for how what happens in the neighbourhood affects the development of the cell in question.

I am not going to repeat what you know – strict CA models lead to emergence as this is the algorithm which generates a self similar structure like a fractal and this works as follows

Most CA models are not strict and do not really show emergence – they are more like GIS models





Here is an example of a diffusion process

(a)

The neighbourhood is composed of 8 cells around the central cell (b)

Place the neighbourhood over each cell on the grid. The <u>rule</u> says that if there is one or more cells developed (black) in the neighbourhood, then the cell is developed. (C)

If you keep on doing this for every cell, you get the diffusion from the central cell shown below.















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Kiril milov, Merch 2020 CASA



Stanilov, K. and Batty, M. (2011) Exploring the Historical Determinants of Urban Growth Patterns through Cellular Automata, **Transactions in GIS**, **15**(3), 253–271





The New Short Termism: Fragmentation of Applications & the New Plurality of Planning

My last set of examples are hardly models at all. They are more or less manipulations of big data. The shift that this has occasioned is from the long to the short term

Most of our models look at the long term and the short term – what happens routinely during the day or occasionally but at an instant – has not been subject to much analysis and simulation, with perhaps the exception of time space budgeting and activity modelling in transport

There is now a new focus in mobility and flow at all scales





There has been a major change too to problems that are more immediate – such as crises as well as routine movement. This has come from massive decentralization and a feeling that the long term is less easy to forecast

I could give you an entire lecture on how all of this is beginning to have an impact on a science of cities but what it means for us is that we can model these new problems but they are much more partial than before. In fact CA models are quite well suited to modelling flows which are discrete – in fact some of the new LUTI style models such as MAT Sims are developed in this style.

Let me show some examples and a possible simulation.























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Olympics Live Tweet Collection

We are collecting all geo-located Tweets that are being sent from the Olympic Park for the period from the Opening Ceremony until the end of the Closing Ceremony. This collection is being carried out by 22 servers collecting as using an alpha version of the discusse.

Each collector updates as the master server requests an update. The total count will be reflected on this page in real-time using WebSockets so keep this page open and watch the collector update. Each counter starts from zero and will take a few seconds to level out after which each counter will update automatically.

Total Collection

0000785,189

Reading fest	
0000164,089	
Horse guards	
0000122,455	
Earls court	
0000111,132	
Aquatics centre	
0000059,529	
Waterpolo	
0000058,200	
Basketball arena	
0000050,845	
Bmx	
0000050,089	



Visualising London's Tweets 3 Months – Jan to March 2011



New York





Paris



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London

Moscow

Future Prospects

- Ok I have given you a glimpse of where I think we lie in terms of urban modelling
- There is little doubt that we are now moving into a world where our focus is much more short term but in time the long term will come to reassert itself as big data from routine transactions begins to mount up and give us change.

Models like UrbanSim and Matsims are key to all this. The science that all this implies is extremely rich but also there is no strong theory to tie it all together





In fact I think there was an assumption 40 years ago when I came into this field that there as a momentum for such a theory of cities and models which would make this applicable.

In fact quite the opposite has occurred – there are signs of theory as for example in new approached to mobility but we do not have new kinds of urban model of a comprehensive nature

The other key development is that urban models do not look at though they will be routinised like GIS – in fact all the applications like MATSIM are tailored to specific applications, the same with Urbansim. SLEUTH for example is not really a model of the same kind.





Moreover policy applications seem to required more elaborate models like Matsims and Urbansim that provide possibilities for partial applications but in the context of a wider simulation.

CA models really cannot do this unless they are linked to suites of models such as the Engelen-White models as they were developed for Murbandy and other projects.

To finish, I think we do stand at a dividing line – where we cannot easily see the way forward – as the age of the comprehensive urban model has passed and now the focus is on tools to build specific models. CA is attuned to this context to an extent but the range of applications is limited.





Resources

Batty, M. (2012) A Generic Framework for Computational Spatial Modelling, Chapter 2 in A. J. Heppenstall, A. T. Crooks, L. M. See and M. Batty, (Editors) *Agent-Based Models of Geographical Systems*, Springer, Berlin and New York, pp. 19-50.

Our blogs at CASA http://blogs.casa.ucl.ac.uk/

My blogs http://www.complexcity.info/ http://www.spatialcomplexity.info/ http://www.simulacra.info/ and others that spin off from this



