SCHOOL OF Geographical Sciences & Urban Planning
ARIZONA STATE UNIVERSITY

Advanced Urban Modeling
GCU 598 (28167) or PUP 598 (28168)
April 26, 2010

Lecture 1

Models & Theories:

The Model Building Process – Understanding, Simulation, and Prediction

A web page will be set up tomorrow to present references and a pdf of each lecture after it has been presented

My own web page is at http://www.casa.ucl.ac.uk/ where various resources will be available

Outline

- What are Models? Relationships to Theory
- Definitions of Models
- A Classification: Icons, Analogs, Symbols,
- Aggregate viz Disaggregate Modelling
- Statics viz Dynamics
- The Paradigm Shift: Aggregates to Agents
- The Model-Building Process
- Facts and Theories, Factoids and Stylized Facts
- Verification, Validation, Goodness of Fit
- Calibration and Estimation

What are Models? Relationships to Theory

A theory is an *abstraction* of some phenomena, usually '*real*' but sometimes imagined in a form that makes the *simplification* or abstraction clear. A model is a simplification of *reality* which takes the theoretical abstractions and puts it into a form that we can manipulate. Simulation is often used to characterise this process of implementation.

In everything we do, we theorise, and more and more frequently we build models to demonstrate theory.

This is all fairly obvious – but the focus on theory is important because theory can be implicit as well as explicit. In fact in our growing quest describe the world through models, theory is tending to become part and parcel of models.

The main reason for beginning with theory is that the conventional wisdom of science begins with theory and then *tests* theory against observations – data. It is impossible to approach the world without prior theory and without getting involved in where theory comes from, let us assume that whenever we model a phenomena we have in mind theory.

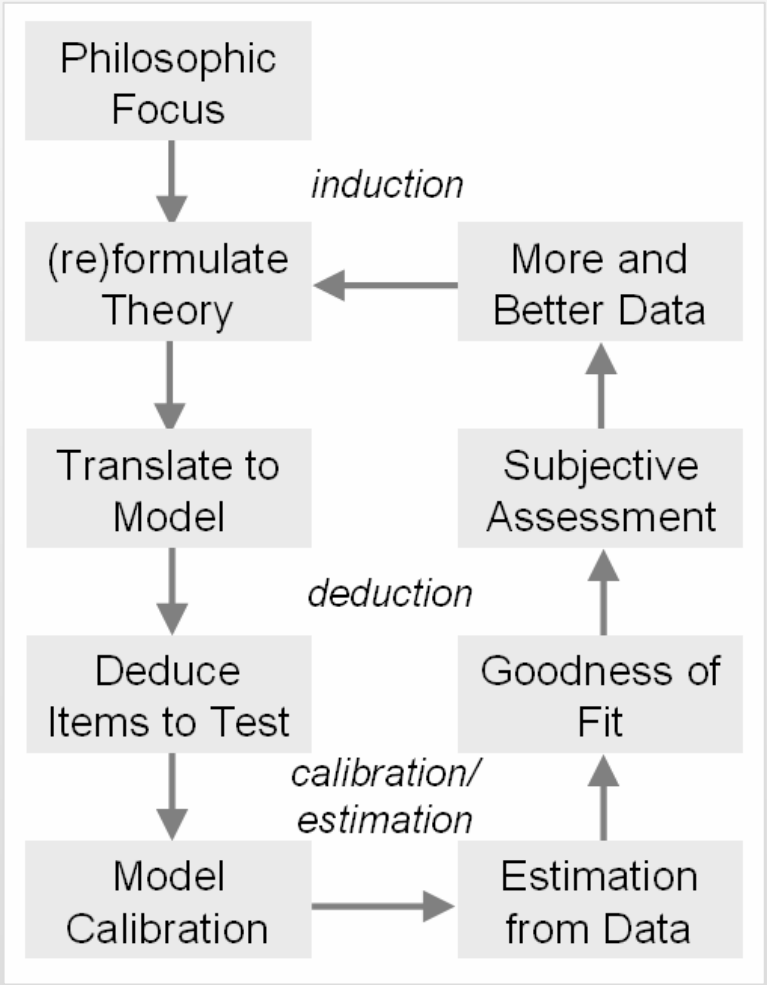
Thus the model- building process is really part and parcel of the scientific process – the scientific method where the current wisdom is that science tests theory by assembling data about reality which is designed to '*falsify*' the theory.

This is scientific method a la Karl Popper. It suggests that data or observations is the ultimate arbiter of good theory. The method implies that this process of testing takes place in systems which are controllable in some science, are not volatile, as in experimental lab contexts. In fact as science has progressed, these conditions appear to be ever more unlikely.

Hence the need for models – for theories in a form other than in the laboratory, where we can perform good testing.

The new form of the laboratory is the computer and instead of experimentation there is simulation. We could and perhaps we should spend time talking about this issue – for by no means all models are simulation models and all science is not based on computers. But increasingly science is intrinsically about computation and this is changing science itself. I also use the term ‘ science’ advisedly, in its most catholic sense ….. another debate perhaps later

Let me get some more terms out of the way – and to do this here is a simple picture of the scientific method.

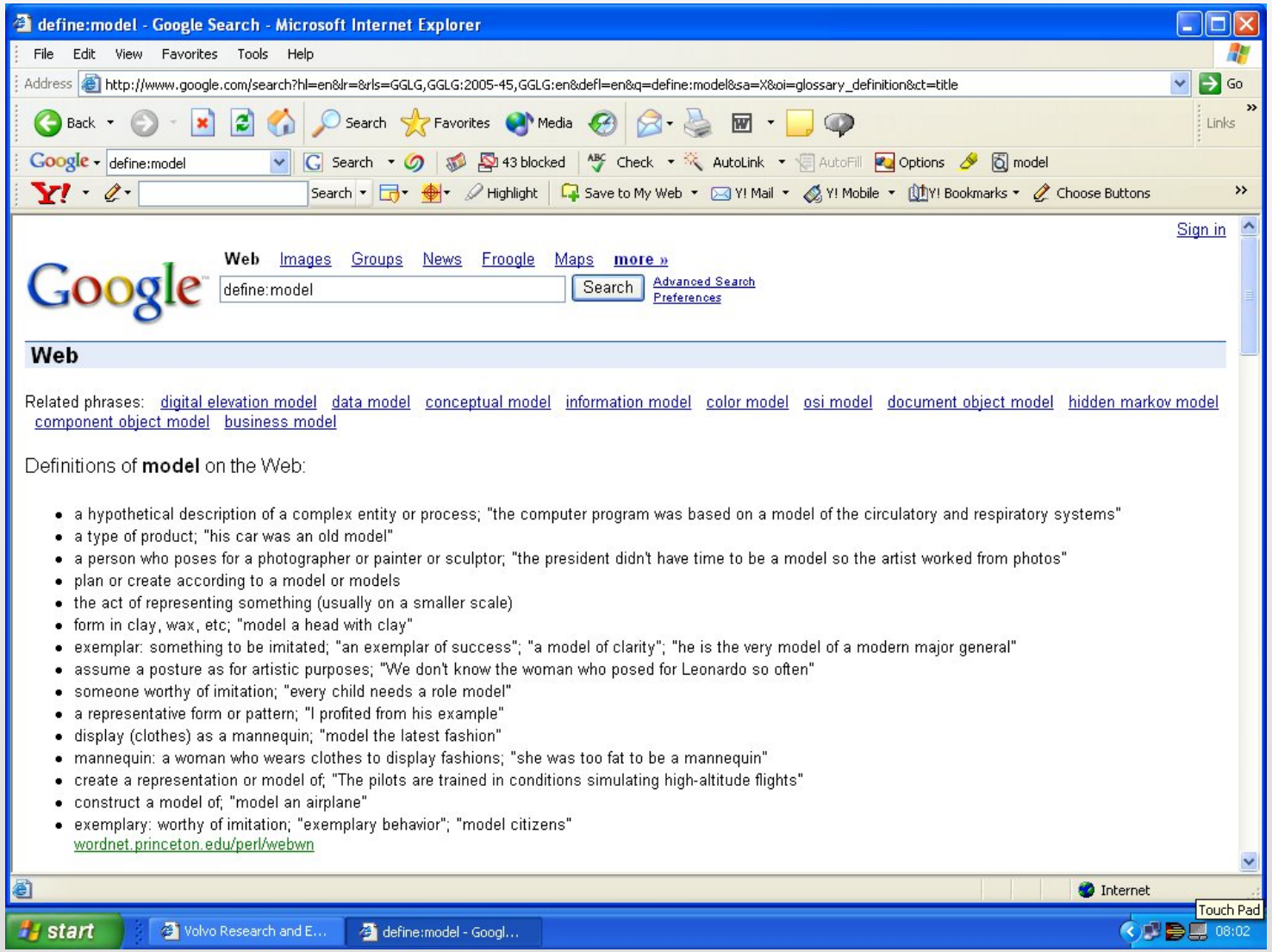


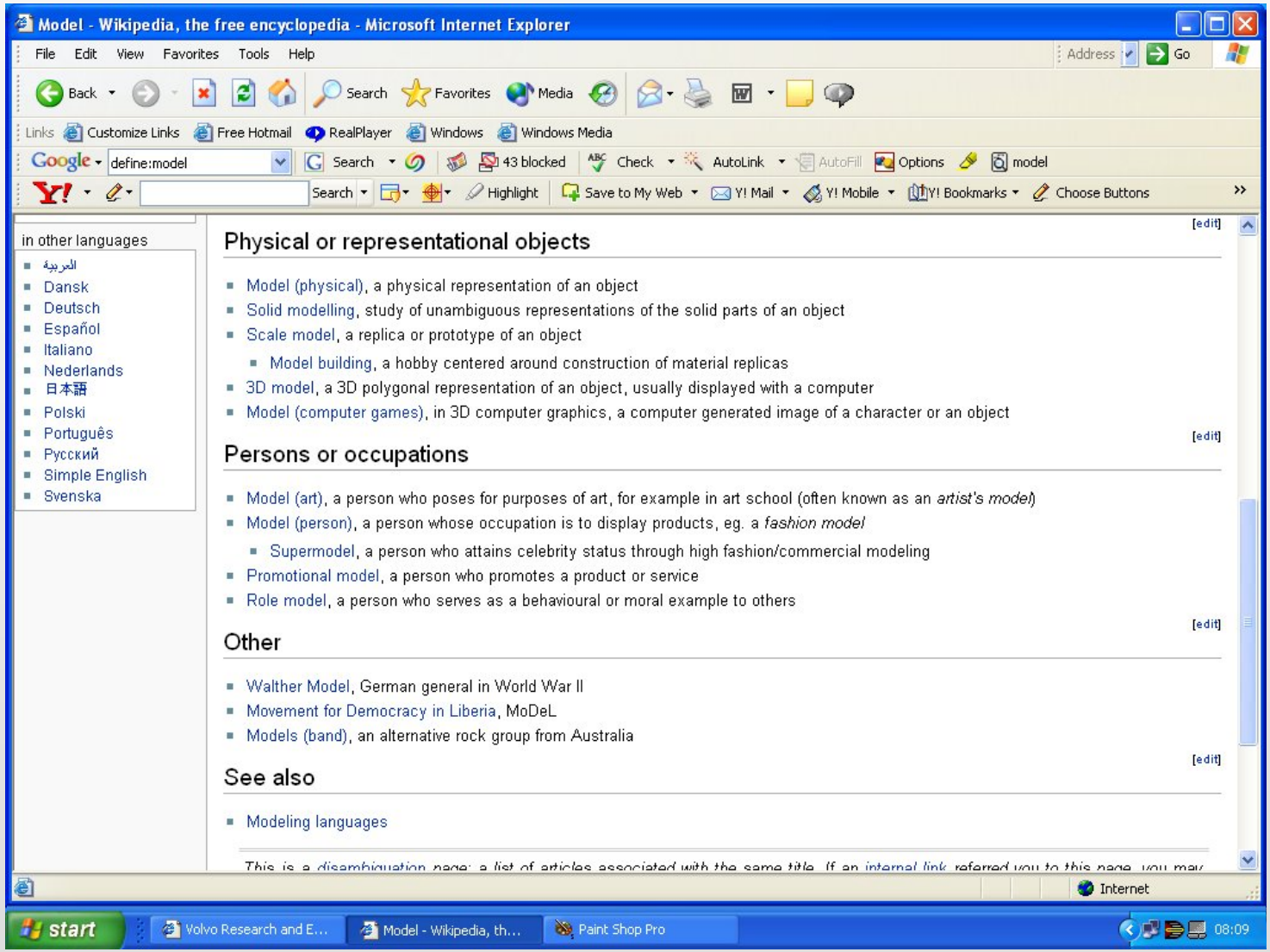
Definitions of Models

There are of course many types of models and although you may think that here we are only going to deal with mathematical or symbolic models, nothing could be further from the truth. Lowry's (1965) paper (see end) that I recommend you read classifies models, and we will draw loosely on his scheme.

There seem to be three or perhaps four different generic ways of abstraction – iconic, analog, symbolic and logical and these categories are not mutually exclusive.

What does Google say about the term ‘model’

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Deutsch
Español
Italiano
Nederlands
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Polski
Português
Русский
Simple English
Svenska
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Physical or representational objects
Model (physical), a physical representation of an object
Solid modelling, study of unambiguous representations of the solid parts of an object
Scale model, a replica or prototype of an object
Model building, a hobby centered around construction of material replicas
3D model, a 3D polygonal representation of an object, usually displayed with a computer
Model (computer games), in 3D computer graphics, a computer generated image of a character or an object
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Persons or occupations
Model (art), a person who poses for purposes of art, for example in art school (often known as an artist's model)
Model (person), a person whose occupation is to display products, eg. a fashion model
Supermodel, a person who attains celebrity status through high fashion/commercial modeling
Promotional model, a person who promotes a product or service
Role model, a person who serves as a behavioural or moral example to others
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Other
Walther Model, German general in World War II
Movement for Democracy in Liberia, MoDeL
Models (band), an alternative rock group from Australia
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See also
Modeling languages
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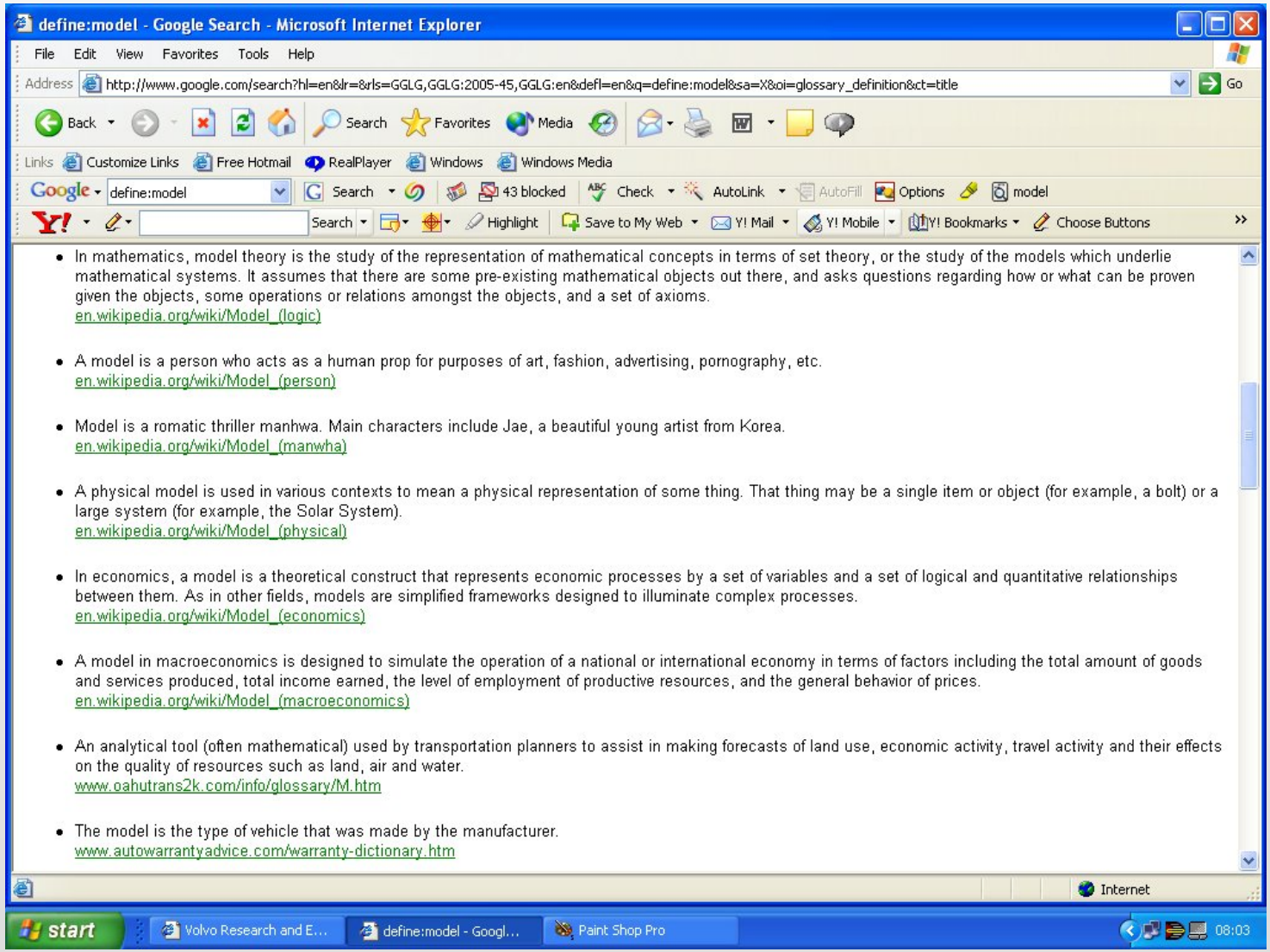
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Links Customize Links Free Hotmail RealPlayer Windows Windows Media
Google define:model Search 43 blocked Check AutoLink AutoFill Options model
Search Highlight Save to My Web Y! Mail Y! Mobile Y! Bookmarks Choose Buttons
• In mathematics, model theory is the study of the representation of mathematical concepts in terms of set theory, or the study of the models which underlie mathematical systems. It assumes that there are some pre-existing mathematical objects out there, and asks questions regarding how or what can be proven given the objects, some operations or relations amongst the objects, and a set of axioms.
en.wikipedia.org/wiki/Model_(logic)
• A model is a person who acts as a human prop for purposes of art, fashion, advertising, pornography, etc.
en.wikipedia.org/wiki/Model_(person)
• Model is a romatic thriller manhwa. Main characters include Jae, a beautiful young artist from Korea.
en.wikipedia.org/wiki/Model_(manwha)
• A physical model is used in various contexts to mean a physical representation of some thing. That thing may be a single item or object (for example, a bolt) or a large system (for example, the Solar System).
en.wikipedia.org/wiki/Model_(physical)
• In economics, a model is a theoretical construct that represents economic processes by a set of variables and a set of logical and quantitative relationships between them. As in other fields, models are simplified frameworks designed to illuminate complex processes.
en.wikipedia.org/wiki/Model_(economics)
• A model in macroeconomics is designed to simulate the operation of a national or international economy in terms of factors including the total amount of goods and services produced, total income earned, the level of employment of productive resources, and the general behavior of prices.
en.wikipedia.org/wiki/Model_(macroeconomics)
• An analytical tool (often mathematical) used by transportation planners to assist in making forecasts of land use, economic activity, travel activity and their effects on the quality of resources such as land, air and water.
www.oahutrans2k.com/info/glossary/M.htm
• The model is the type of vehicle that was made by the manufacturer.
www.autowarrantyadvice.com/warranty-dictionary.htm
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Model, models, or modeling may refer to:
Contents [show]
Wiktionary has related dictionary definitions, such as: model
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Abstractions, concepts or software
Model (abstract), an abstract or conceptual object used in the creation of a predictive formula
Mathematical model
Scientific modeling
Model Driven Engineering, a software development technique based on abstract models
Metamodeling, a model is written in the language of its unique metamodel
Molecular modelling, used to mimic the behaviour of molecules
The Standard Model, the theory in particle physics which describes certain fundamental forces and particles
Model building (particle physics)
Computer model, a computer program which attempts to simulate an abstract model of a particular system, usually builds upon a mathematical model
Model theory, study of the representation of mathematical concepts
Mental model, a person's cognitive representation of an idea or thought process
Modeling (NLP), a process in neuro-linguistic programming
Similitude (model), in engineering, used in the scientific testing of physical models
Analogical models
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A Classification: Icons, Analogs, Symbols

Iconic models are representations that visually convey what the real things looks like – maps are the classic example – these are largely representations – they may have some symbology but they are scaled down versions of the real thing.

Symbolic models represents system in terms of the way they functions, often through time and over space – these models are invariably mathematical.

Analog models are a half way house between iconic and symbolic. The key issue is that they take a representational and/or functional form of one system and apply it to another.

e.g. analogies between physical and human systems – the flow of blood in analogy to hydrodynamics developed for models of the atmosphere, traffic flow as an analog of an electrical network, and so on.

Logical models are symbolic in a sense but are based on causal connections composed of rules. We can mix, of course, any of these four types.

The reason why the term model has become so significant is that computers are increasingly being used as the ‘container’ or ‘media’ for many models as our world becomes digital.

Computers mean that iconic, analog, symbolic and logical models merge into one another, so for example we can have iconic models but built of mathematical structures as in GIS

And computer models are being generalised to all sorts of other things that we never used to call models – to plans, to processes of participation etc.

Aggregate viz Disaggregate Modelling

50 years ago when models first became identifiable as a distinct activity in science, and as the social sciences embraced them, they were usually statistical summaries or aggregations of elemental units.

Good examples were economic models based on macro economics, e.g. Keynesian models, econometric models

Population models, models based on social physics

There has always been a quest however to disaggregate – meaning that the model needs to be specified in more detail. Let me take an example – models of retail systems, called shopping models

Shopping trips = f (Population, Floorspace, Distance)

from zone i where people live to zone j where they shop	zone i where people live	zone j where people shop	from zone i to zone j

We might want to disaggregate the data into detailed types of population and detailed types of shopping, different transport networks and so on.

As computers have become ever faster and larger in terms of processing power, such models have become more and more disaggregate – in principle although data remains a constraints.

In fact as disaggregation has proceeded, models have changed in focus and a new stream of model where the fundamental elements themselves can be represented have become popular.

These are based on objects – or agents – where every element can be simulated – and we will say a lot more about these later in the week.

Statics viz Dynamics

In passing, it would be remiss not to make the distinction between statics and dynamics. Models in social systems have tended to be static – comparative static or cross sectional as they are called in economics – with assumptions about that systems tend towards equilibrium.

In the last 20 years, all this has been thrown up in the air and dynamics has come onto the agenda This has implications for spatial systems where time has not been part of representation and analytical modelling.

The Paradigm Shift: Aggregates to Agents

I am not going to talk this morning about this paradigm shift but will do so later, but just to flag these ideas, in later lectures, we will build

- temporally dynamic models on fine scale spaces called cellular automata or CA models

- temporally dynamic models where individuals or objects move in space – agent-based models ABM or multi-agent models MAS

The Model-Building Process

In later talks and discussions, we will return to the model building process and examine processes for defining a problem, theorising about the problem, formulating a model, operationalising the model, confronting the model with data, calibrating the model to the data, testing the model's fit, taking the model elsewhere to truly test it, improving the model by extending the theory, and reiterating the process in this way. But here we need to say something about facts and how we fit models to facts of different sorts.

Facts and Theories, Factoids & Stylized Facts

- Generally observations of the system being modelled or simulated are assembled and the model's predictions are compared against these 'facts'
- Facts are publicly agreed sets of observations over which there is 'no' disagreement
- Facts can range in quality from well defined observations to highly speculative pieces of data.
- Factoids and stylized facts are two types of observation that are sometimes used in testing a model's predictive abilities

Factoids

1. A piece of unverified or inaccurate information that is presented in the press as factual, often as part of a publicity effort, and that is then accepted as true because of frequent repetition.
2. combining the word "fact" and the ending "-oid" to mean "like a fact".
3. Factoid has since developed a second meaning, that of a brief, somewhat interesting fact, that might better have been called a ‘factette’.
4. A 'factlet' is a fact that is tiny and trivial, and also correct.

Stylized Fact

In social sciences, especially economics, a stylized fact is a simplified presentation of an empirical finding. While results in statistics can only be shown to be highly probable, in a stylized fact, they are presented as true.

A stylized fact is often a broad generalisation, which although essentially true may have inaccuracies in the detail. Highly applicable to the assumptions of agent-based models which may not be verifiable but plausible

Verification (a model matches its design)

To check, confirm or prove the truth of something. To establish, prove, substantiate, attest, corroborate, support, confirm.

Validation (a model matches the data)

To meet some criterion/criteria associated with the model and or the data/observations. In general, validation is the process of checking if something satisfies a certain criterion. Examples would be: checking if a statement is true, if an appliance works as intended, if a computer system is secure, or if computer data is compliant with an open standard. This should not be confused with verification.

Goodness of Fit

A well defined measure of how the model's predictions match the known observations of facts, typically some measure of difference between predictions and observations.

Predictions are any outcome of the model, past, present or future

Calibration and Estimation

Calibration is the generic process of validation and verification. Estimation is the process or method of generating a precise estimate of some parameter characterising the model.

Other Issues

Consistency and reliability –with reliability is the consistency of your measurement,

I don't think there is a coherent discussion of all these issues *per se* as they are pieced together from multiple sources.

Sensitivity Testing
Process Modelling
Parsimony v richness
Scale, aggregation …. Space and time

Background Reading

I will put this material up on the web tomorrow but there are five papers worth looking at

Batty, M. (2009) Urban Modeling, in R. Kitchin and N. Thrift (Eds) **International Encyclopaedia of Human Geography**, Volume 12, Elsevier, Oxford, 51–58.

Batty, M. (2008) Spatial Interaction, in K. K. Kemp (Editor) **International Encyclopaedia of Geographic Information Science**, Sage. Los Angeles, CA, 416-418.

Batty, M. and Torrens, P. (2005) Modelling and Prediction in a Complex World, **Futures**, **37** (7), 745-766.

Lowry, I. S. (1965) A Short Course in Model Design, **Journal of the American Institute of Planners**, **31**, 158-165.

van der Leeuw, S. E. (2004) Why Model? **Cybernetics and Systems: An International Journal**, **35**, 117-128

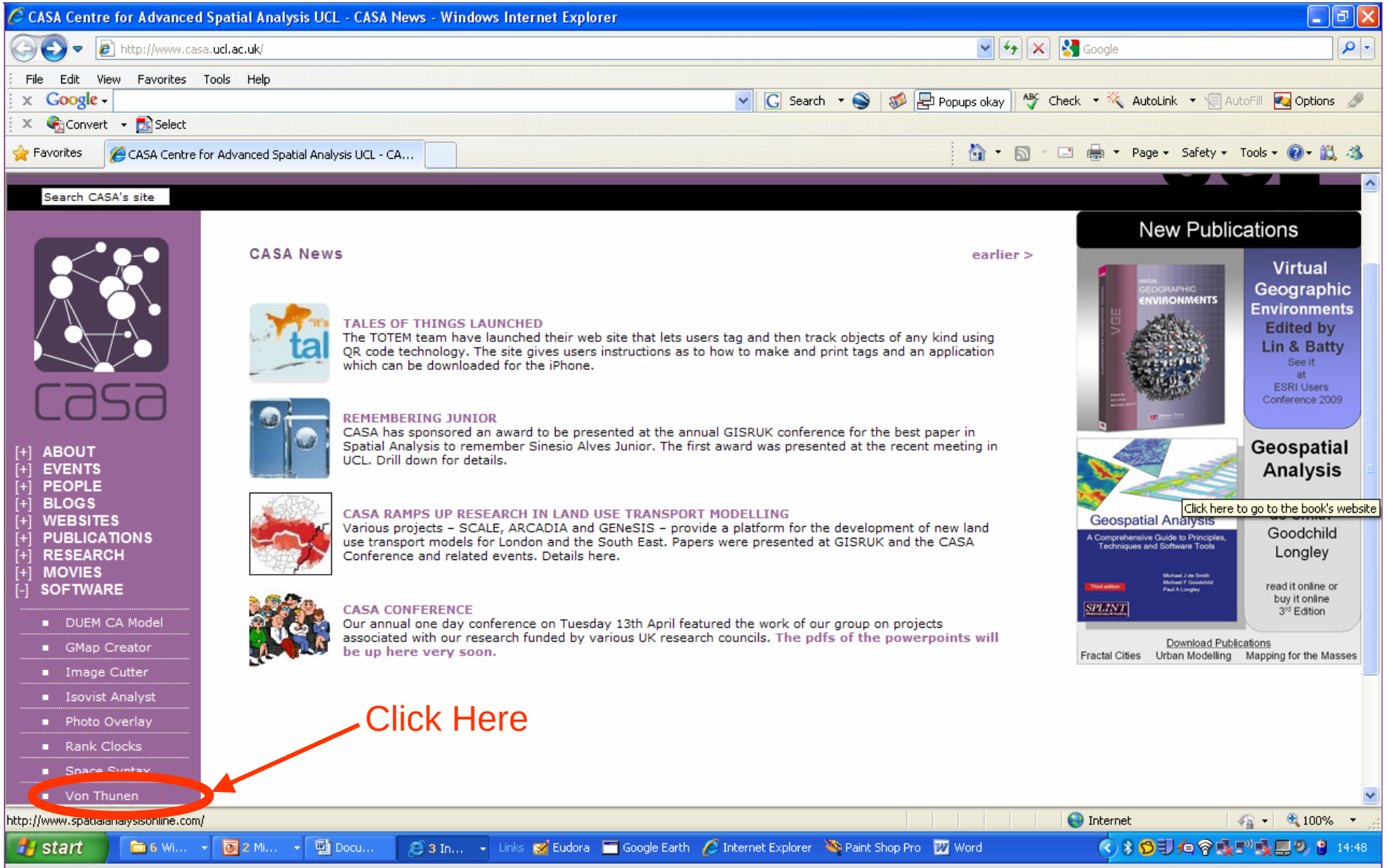
And if you want some old background you can download my book Urban Modelling (1976) from our web site at www.casa.ucl.ac.uk/urbanmodelling/

Something else to do in anticipation of the next lecture

Look at Phil Steadman's von Thunen model program on our web site

And download it and run it – it will take you five minutes to work it out

Next time we will look at the role of distance and competition with respect to how these key spatial structuring variables form the basis of a wide class of urban models and von Thunen's model is the simplest and first expression of all this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Isovist Analyst
Photo Overlay
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Space Syntax
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TALES OF THINGS LAUNCHED
The TOTEM team have launched their web site that lets users tag and then track objects of any kind using QR code technology. The site gives users instructions as to how to make and print tags and an application which can be downloaded for the iPhone.
REMEMBERING JUNIOR
CASA has sponsored an award to be presented at the annual GISRUK conference for the best paper in Spatial Analysis to remember Sinesio Alves Junior. The first award was presented at the recent meeting in UCL. Drill down for details.
CASA RAMPS UP RESEARCH IN LAND USE TRANSPORT MODELLING
Various projects – SCALE, ARCADIA and GENeSIS – provide a platform for the development of new land use transport models for London and the South East. Papers were presented at GISRUK and the CASA Conference and related events. Details here.
CASA CONFERENCE
Our annual one day conference on Tuesday 13th April featured the work of our group on projects associated with our research funded by various UK research councils. The pdfs of the powerpoints will be up here very soon.
New Publications
Virtual Geographic Environments Edited by Lin & Batty
See it at ESRI Users Conference 2009
Geospatial Analysis
Click here to go to the book's website
Goodchild Longley
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UCL Centre for Advanced Spatial Analysis - Windows Internet Explorer

http://www.casa.ucl.ac.uk/software/vonthunen.asp

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- DUEM CA Model
- GMap Creator
- Image Cutter
- Isovist Analyst
- Photo Overlay
- Rank Clocks
- Space Syntax
- Von Thunen

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The von Thunen Model

Philip Steadman from the Bartlett Grad School and a team at the Open University back in 1998 developed a sketch model based on the **von Thunen's theory of land rent**. This was designed to teach beginning students of technology about the land use structure of cities in urban economic terms. It is so simple and so intuitively attractive that we still use it a lot to demonstrate the idea of how simple models can be brought alive by simple software. An implementation of the von Thunen model was first implemented in the IDRISI software by Randy Dodson at the **NCGIA** in the early 1990s from an idea by **Waldo Tobler**. Following the instructions below, this program can either be run from this web site or it can be downloaded for use on your own desktop.

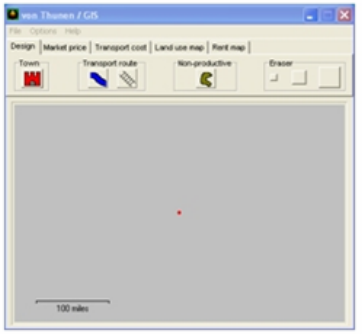
In essence what this software does is present the user with a blank homogeneous plain, in the terminology of urban economics - a landscape on which a central place or market or town is 'planted'. The user can then use the drawing tools in the Design mode to add more towns, transport routes, rail routes, and non-productive land which act as constraints on the distribution of land uses. If there are no constraints (other than just the placement of the central node), then the model generates a symmetical land use pattern around the central town. The land use pattern depends on how the transport and market price lines - bid rent curves in the jargon - interact with each other.

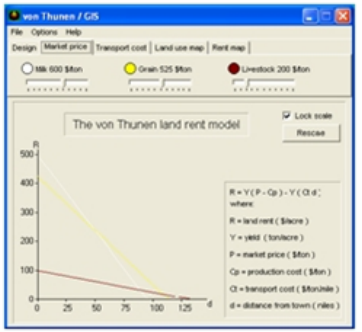
Essentially the von Thunen model assumes that land use is determined by the market price less the transport cost and from the interaction of these bid rent curves, a land use will dominate at any point a given distance from the town (or from competing towns). You can also alter the shape of the bid rent and cost curve using sliders. You can then display the land use map and look at the map as a 3-D surface of rents. You can manipulate this surface using sliders as well in oblique projection. The various pictures to the right (--->>>>) show you the sequence of steps in the program using a single town - the red dot in the middle of the top screen shows the location, and then the bid rent curves which the user can adjust. The circular town configuration of land uses is shown below and finally this can be seen in 3-D. You can import map pictures of real places and run the von Thunen model with towns and roads etc. planted on such backcloths. You can access the drop down menus to do this and you can also change the weights that way and incorporate a fuzzy distance calculations.

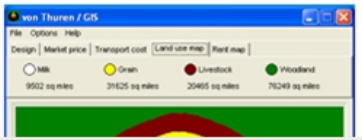
Click on this icon to the left to run the software

Click on this icon to the left to download the data and the software

The following is an example with various distortions added by the user to the homogenour plain produced using the application:







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If there is time,
I will answer any

Questions

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