LECTURE 1:

1. Why are successful cities dense, expensive, and with few large green patches?

Cities are usually located in areas where growth and productivity of the people thrive. This is as a result of the causal effect interaction between spatial processes and spatial patterns. When a location has a good developmental potential, it attracts more industrial activities. This industrial localisation leverage on their agglomeration to maximise the land use potential by sharing facilities, innovations, services etc, which consequently helps them maximise utility and productivity.

Furthermore, these productive activities are expected to attract people, as they move closer to such are because of the economic prospects. There is in turn, a causal-effect relationship between the activity centre and households. For instance, the industries, can provide economic means for the households via employment and also provides goods and services. In return, the households can provide a market and labour for the industries. In this sense, contiguity and proximity of these activities are necessary and encourage influx of more people to the Central Building District for opportunities.

Because of how cities evolve, there is always more people at the CBD, while the population, commercial activities reduce as one moves outward, due to distance decay effect. Cost of travelling to the CBD increases as one moves outward. This encourages the conversion of green spaces into buildings because of the higher land value and needs for commercial activities, at the CBD while agricultural activities are mostly located at the peri-urban areas.
However, this trend has been found to change slightly in some developing countries as people occupy outer areas due to cheaper cost.

2. Why do cities need policy interventions?

Cities face many challenges, due to their higher population and activities. These problems are especially more pronounced in developing countries with poor coping strategies and policy implementation. Because of the density of activities, many externalities are expected. Some of these include, congestion, pressure on public amenities, increase in crime and social vices, pollution etc.

To curb excesses from the effects of these, policies have to be put in place to guide the growth and ensure sustainable city. Policies which can be formulated, might, for instance, encourage more people to live in the outskirts. Cost of parking can also be increased to decongest traffic at the centre. Transportation network can be improved upon too. A typical example is the länsimetro which spans across Helsinki through to Espoo, Finland. Which such in place, more and more people can live farther and still be able to work at the centre because of the shrunk distance by the metro. This helps to cushion the distance decay effect.

From the foregoing, policy intervention can help to incentivise or disincentivise people in necessary situations for sustainable urban development. Tree planting can also be encouraged to increase green areas. There have been many scenarios whereby, patches of green areas have been reserved even in a very urbanised area.

LECTURE 2:

1. **What is a spatial weight matrix(SWM), what assumptions does it make, and how is it used?**

A spatial weight matrix is used to evaluate the degree of similarity between values and locations. This is referred to as spatial autocorrelation and spatial weight matrix does this by exerting a neighbourhood structure on the data. These neighbours are usually defined by binary numbers – 0 and 1. With 0 as not neighbour and 1 as neighbour. It is also important to standardise the rows, afterwards.

A typical assumption of SWM is that the fewer the neighbours, the stronger the influence of a location. In GeoDa, the observations/location are characterised by rows and columns in the matrix. Here, the neighbour is 1 and the location is 0. In description of neighbour, contiguity and distance are considered. Contiguity as it the name suggests, refers to the sharing of borders. This includes the rook and queen.

The rook considers the edges while the queen considers the edges and vertices, when deciding which spatial element is a neighbour. Contiguity is directly more suitable for polygon, however, when dealing with points, assumptions can be made about their areas of influence (i.e. the Thiessen polygon). A grid polygon can also be employed but might not be suitable to large scale analysis (e.g. cadastral scale), because great details are required at such micro level which might be lost in the process of using the polygon grid and aggregating the points into polygons

Distance on the other hand, considers the distance band and k- nearest neighbour. It is also able to handle polygon and points directly.

2. **What is spatial clustering and what are the various kinds of it?**

Spatial clustering is a phenomenon that describes the homogeneity of groups of observations, according to their attribute values. It shows if they are clustered or dispersed. An instance of spatial clustering is the clustering of a disease or crime location data. Here, it clusters the geometries of areas with similar attributes. It can be used to understand the hotspot of occurrence of a phenomenon, other than random distribution.

They can either be positive, negative or random. Positive distribution shows that there is a cluster while negative infers a dispersion. Positive spatial autocorrelation follows Waldo Tobler's premise that everything is relate but near areas are more related than the distant areas. Here, the clusters could be high-to-high values or low-to-low values while negative spatial autocorrelation is depicted by high-to-low or low-to-high spatial outliers.

Random shows occurrence by chance. Spatial clustering can be assessed by techniques by partitioning, hierarchy or locality-based. Such include the Global and local spatial autocorrelation. The previous captures the overall scenario while the latter zooms in to assess the local clusters.

LECTURE 3:

Spatial Statistics: Spatial Regression Models:

1. What is Spatial regression?

Spatial regression is a statistical technique that is used for encapsulating the spatial dependency that occurs in regression analysis. It does this by giving details about the spatial relationships between the included variables. Furthermore, it prevents several statistical issue which include unreliable significant tests and inconsistent parameters. spatio-temporal predictions can then be made based on this spatial relationships.

The spatial dependency can be included into the regression model as the common relationship between dependent and independent variable, or as the relationship between the dependent variable and its spatial lag or spatial error term.

Also, spatial heterogeneity between the dependent and independent variables can be captured by the Geographically Weighted Regression which localises spatial regression by disaggregating the parameters by the analysis' spatial units.

2. What are the differences between the spatial error, spatial lag, and spatial Durbin models?

Spatial error model(also, nuisance dependence) captures the spatial dependence with spatial autocorrelation. It is suitable when one is interested in correcting potential effect of bias by spatial autocorrelation, because of the use of spatial data(regardless of the spatiality or non-spatiality of the model). Spatial lag model, on the other hand, is a model which incorporates a spatially lagged dependent variable(Wy) as an extra regressor to the spatial dependence in the standard linear regression model. It is suitable when one is interested in evaluating the presence and strength of interaction. Lagrange Multiplier (LM) or Rao Score can be used for distinguishing between spatial error models and spatial lag models.

In addition, Spatial Durbin Model combines the two above-mentioned models - spatial error model and spatial lag model- by taking the advantage that it is possible to define a spatial error model in spatial lag form. It does this by including the spatially lagged predictors(independent variables), however, the parameters are checked by the common factor constraints.

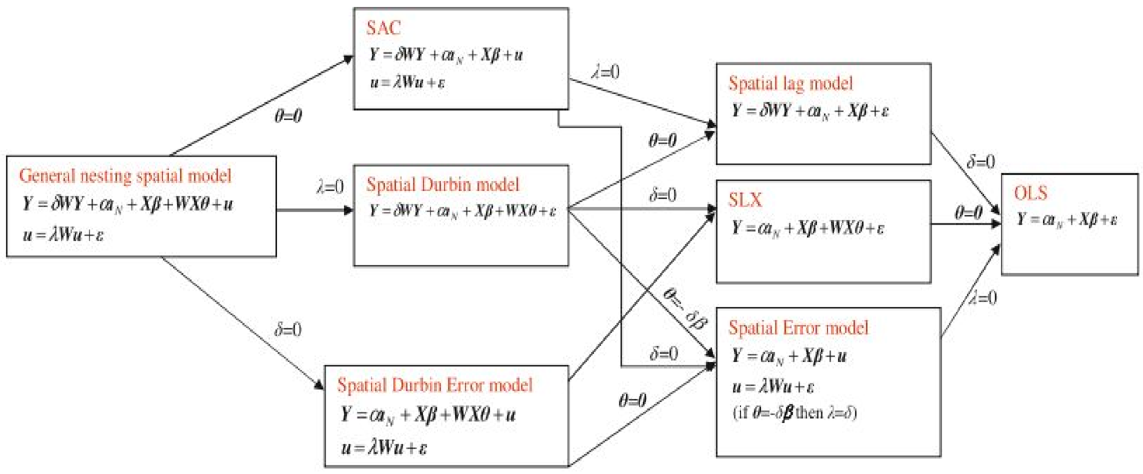

Fig. 2.1 The relationships between different spatial dependence models for cross-section data (*source* Halleck Vega and Elhorst 2012)

Model	Spatial Interaction effects	#	Flexibility of spatial spillovers
Spatial Error Model	Wu	1	Zero by construction
Spatial lag model	WY	1	Constant ratios
Spatial Durbin Model	WY, WX	k+1	Fully flexible

LECTURE 4:

Spatial Statistics: Geographically weighted regression.

1. What is spatial non-stationarity in regression coefficients and how does geographically weighted regression address it?

Spatial non-stationarity in regression coefficients explains the modelled relationships that are variable spatially(across space). This causes explanatory variables to have differential effects across space, which consequently, impacts the output of a model. In other words, spatial non.stationarity is a situation whereby the simple global model is not able to explain the relationship of some variables sets. Therefore, the model itself, has to vary over space to reflect a realistic structure within the data.

To deal with this, Geographically Weighted Regression(GWR) fits potentially various coefficient value for per observation, by using spatial weight. This technique calibrates calibrates multiple regression model which permits various relationships over space, and therefore, enables the representation of this variation by estimating local coefficients.

2. Can you give some examples of spatial non-stationarity in real world phenomena?

One real world example is assessing housing price, because it is immobile. Hence, variation in traffic conditions, socioeconomic situation, resource richness across different states can result in a scenario whereby the relationship between the dependent and independent variables(predictors) is not constant spatially. Global models might not reflect the true picture at a regional level which could yield a misleading and unrealistic result. GWR attempts to deal with this by creating regression models at every point with estimation of varying coefficients.

Another example of spatial non.stationarity could be relationship between car ownership rates and social class and unemployment in Finland. With a universal model developed from this, it might difficult to explain local variation across space because social class and male unemployment vary, at various spatial scale and also from municipal to municipal.

Relationship between land value and accessibility can also be another instance as this varies over space. Others can include:

- Species distribution which could depend on many predictors such as Slope Aspect , climate, which vary across space.
- population density distribution.
- spatial non-stationarity in the relationship of a sea life(e.g fish) and temperature, distance from shore, whereby the direction and the significance of the relationship might vary over an entire area of interest.

LECTURE 5:

How do cellular automata see and explain the world?

Simply put, Cellular automata is a concept which sees the world as a plane with grids which consists of cells. Each of the cells is assumed to have one of two colours(e.g black or white). Furthermore, the cells change colour based on the colour of the neighbouring cells. The interaction with neighbours are executed according to some predefined rules. A more complex scenario with more colours can also exist. Overall, the cells change temporally according to the transition rules. Cellular automata can be one row dimension of cells or multiple dimensional grid of cells.

They are able to explain complex spatial behaviour in the world in a fascinating way. Basic rules could yield some haphazard patterns, causing some uncertainties in predictions. However, a careful and proper design can also give realistic results by stably and steadily predicting evolution of patterns overtime, with careful inter-neighbours interactions. A constraint is usually imposed also, to achieve this realistic result.

This concept has been used in modelling traffic flow, with the development of mechanisms of traffic control which can help to decongest the roads. This considers binary scenario where you have an empty road as 0 and roads occupied by cars as 1, which can be white and black respectively. However, this can be made more complex to allow for cars at various speed(e.g, 1-20), which can then be represented as a colour spectrum(e.g green to red).

Another example where cellular automata can explain the world is in the modelling of wildfires as they spread and predicting their path of burns and burning rate overtime.

In addition, two-dimensional cellular automata has been used to understand both the physical and human world. An instance is in the evolution of a city which can take from simple to very complex rules and can also take into cognisance, the various land use types, morphology of the city, presence of hindrances(such as hills, lakes etc). By using these various interaction rules such as rook(von Neumann) and queen(Moore), we can predict phenomenon like urban sprawl. With this, policy makers can formulate a more appropriate sustainable urban planning.

Perhaps, the entire universe is a cellular automaton which expands steadily?

LECTURE 6: AGENT-BASED MODELS

1. What are agent-based models and how do they differ from cellular automata?

Agent-based models are models are very strong simulation technique of modelling that have proved to be useful in real world scenarios. Here, agents are used as collection of independent decision-making bodies for modeling a system. Each of the agents make evaluates its situation and decide based on a set of rules. Agent-based models mainly aims to simulate the potential characteristics of agents which cannot be decided from the rules controlling the individual agents.

Agent-based models are quite similar to cellular automata but different in many ways. Neighbourhoods/grids in cellular automata are fixed while in agent-based modelling, the nearest neighbours changes over time. This is because, the agents in agent-based models have the freedom of motion and interaction between one another and their environment. Agent-based models seem to provide more complex agents while cellular automata basically proceed with a few rules which uses the neighbourhood states to update the state of the system.

Because of these more complex rules and interactions in Agent-based model, it will be expected to yield a more realistic simulation(especially in social sphere which is very complex) than cellular automata which employs a much more simplistic approach in determining the evolution of the system based on neighbourhood state.

2. What sort of point does Schelling's segregation model make?

Schelling's segregation attempts to create independent agents or entities that act based on fairly simple rules which could be learning or random interaction rules. This simple rules can eventually yield complex overall eventual structure or pattern. The model shows that subtle interaction amongst agents can cause segregation.

This patterns evolve by agents assessing their present position depending on their happiness rule which is based on the neighbouring cells. The unhappy agents can change position with one another. This goes on till the agents are happy and this phase depicts the equilibrium result. The eventual result is based on the rule of happiness. An example would be that I want all my neighbours in the class to be international students. This will expectedly result in a complete segregation. Such complete segregation can even be cause by little preferences.

An example of this can be seen in everyday life in school and in our cities. For instance, Africans and Arabs are mainly in the eastern part of Helsinki while the native finns and europeans tend to be in the western part. This does not mean that each of the groups are racist but might have their own individual preferences which aggregate into complete segregation overtime.

This shows that if an area starts as being very segregated, it will be kept that way by natural interaction. Therefore, if diversity is preferred or wanted, it should start at the earliest phase. Furthermore, there might be need to intervene to sustain the diversity and amend the situations as the system evolves. This maybe be due to subtle discrimination and not necessarily pronounced or deep discrimination. This scenario is also applicable to local and international students in any University such as the University of Helsinki.

LECTURE 7: FUZZY COGNITIVE MAPS

1. **Does a fuzzy cognitive map represent a phenomenon or the perception of a phenomenon by a group of experts?**

A fuzzy cognitive map attempts to represent a phenomenon but is usually based on the perception of a group of experts. By and large, fuzzy cognitive map can represent both a phenomenon or the perception of it by experts. They are used for causal relationship representation(directed and weighted connections) amongst variables in a network which are usually determined and described by these experts.

These variables could represent phenomena, insightful concepts, management decisions or a group of experts' perception and knowledge of the interactions among the variables that directly or indirectly affect the occurence of a phenomenon. Furthermore, such variables could be quantitative or qualitative. Thus, a fuzzy cognitive map represents knowledge symbolically and link processes, phenomena e.t.c

2. **In which cases the two above-mentioned alternatives might converge?**

The above two alternatives might converge if there is no discrepancy between the experts' perceptions of reality or phenomenon and the phenomenon itself. In other words, a fuzzy cognitive map representing the perception of a phenomenon by experts could also be representing the phenomenon if the perception of the experts aligns with the reality of the phenomenon. This could be attainable when the experts are credible and their knowledge are justifiable.

Furthermore, the systematic connection of a fuzzy cognitive map could represent a phenomenon if the knowledge bases could grow. This is particularly true in the soft knowledge areas where the concepts of the phenomenon are fundamentally fuzzy. Such include military, public welfare, political science, organisational theory etc.