Assessment for CASA0002 – Urban Simulation

Deadline: 23rd April 11am.

Word Limit – 3,000 words

The following assessment is designed to assess your understanding and application of the different urban modelling methodologies introduced in the course. The questions are based on the coursework developed during the course and posted in Moodle. This should be your main source to complete the assessment, since the necessary codes for the assessment were reviewed during the practical sessions. Carefully explain and illustrate your analysis with appropriate graphs and plots. The assessment should not exceed 3000 words in total. (References, numerical tables and data plots do not count towards the total number of words.)

The assessment will guide you to critically investigate the resilience of the London's underground as a network and the methodological limitations. You will do this in two ways. In the first part, you will only take into consideration the infrastructural network, where stations are connected through only one link, regardless of the number of lines connecting the stations. In the second part, you will consider the commuting flows, and discuss the impact of the analysis on the number of people moving from one part of the city to another. Then, you will recompute the flows using spatial interaction models according to different scenarios described below and discuss the vulnerability of the network under these new scenarios.

Structure: please follow the structure provided below for your work.

Part 1: London's underground resilience

I. Topological network

In this part, you will evaluate the resilience of the London's underground through the removal of stations that can potentially make the underground vulnerable. Through the procedure outlined below you will investigate which are the stations that are most critical for the functioning of the underground, and which methodology is more appropriate to finding these stations.

I.1. Centrality measures:

Select 3 centrality measures to characterise nodes, aiming at identifying the most important nodes in the underground network. Give the definition of each of the measures (including their equation), put the measures into the context of the underground, and why they will allow you to find the stations that are most crucial for the functioning of the underground. Compute the measures for your nodes in the network, and give the results in a table for the first 10 ranked nodes for each of the 3 measures.

I.2. Impact measures:

Find 2 different measures to evaluate the impact of the node removal on the network. These need to be global measures referring to the whole network and not to specific nodes or links. Explain whether these two measures are specific to the London underground, or whether they could also be used to evaluate the resilience of any other network.

I.3. Node removal:

For each of the centrality measures selected in I.1. remove at least 10 nodes following two different strategies. A) Non-sequential removal: using the table created in I.1. remove 1 node at a time following the rank in the table, i.e. from the most important one to the 10th most important one. After each removal, evaluate the impact of the removal using your two measures in I.2. and proceed until you have removed at least 10 nodes. B) Sequential: remove the highest ranked node and evaluate the impact using the 2 measures. After removal, re-compute the centrality measure. Remove the highest ranked node in the new network and evaluate the impact. Continue until removing at least 10 nodes.

Report the results of the 2 strategies in one plot, and critically discuss the following: which centrality measure reflects better the importance of a station for the functioning of the underground, which strategy is more effective at studying resilience, and which impact measure is better at assessing the damage after node removal.

II. Flows: weighted network

In this section, you will include passengers into the underground, and assess whether different measures need to be used when flows are considered. The network to use in this section is the weighted network given to you in the coursework, where the flows of passengers were assigned to the links between stations.

II.1. Consider the centrality measure derived in I. indicating the most relevant stations for assessing the vulnerability of the underground. What would you need to do to adjust this measure for a weighted network? Recompute the ranking of the 10 most important nodes according to this adjusted measure. Do you find the same ones as in I.1?

II.2. Now consider the measure for assessing the impact of node removal. Would you adjust the measure for a weighted network? If yes, how? Propose a different measure that would be better at assessing the impact of closing a station taking into consideration the passengers.

II.3. Remove only the 3 highest ranked nodes according to the best performing centrality measure found in I.1. Evaluate the impact according to the 2 measures in II.2. Repeat the experiment for the highest 3 ranked nodes using the adjusted measure. Critically discuss which station closure will have the largest impact on passengers, referring to your measures and results.

Part 2: Spatial Interaction models

For this section, you will be given a "symbolic" population and the number of jobs for the stations in the underground. You will also be given the number of people that commute from one station to another, through an OD matrix.

III. Models and calibration

III.1. Briefly introduce the spatial interaction models covered in the lectures using equations and defining the terms, taking particular care in explaining the role of the parameters.

III.2. Using the information of population, jobs and flows, select a spatial interaction model and calibrate the parameter for the cost function (usually denoted as β). It is essential that you justify the model selected.

IV. Scenarios

IV.1. Scenario A: assume that Canary Wharf has a 50% decrease in jobs after Brexit. Using the calibrated parameter β, compute the new flows for scenario A. Make sure the number of commuters is conserved, and explain how you ensured this.

IV.2. Scenario B: assume that there is a significant increase in the cost of transport. Select 2 values for the parameter in the cost function reflecting scenario B. Recompute the distribution of flows.

IV.3. Discuss how the flows change for the 3 different situations: scenario A, and scenario B with two selections of parameters. Which scenario would have more impact in the redistribution of flows? Explain and justify your answers using the results of the analysis.