

## EPA133a. Advanced Simulation

### Assignment 4. Network Analysis

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#### Introduction

In this Assignment, you will analyse the transport network in Bangladesh and present the results. The focus is the vulnerability and criticality of the network (i.e., road segments and bridges). It is important to understand how busy it is on different roads and which parts of the roads are most heavily used for goods transportation, i.e., which roads or parts of roads have a high percentage of truck traffic (relating to criticality). Of course, we are interested in presenting the results in relation to the properties of the road itself, i.e., the location and quality of bridges (relating to vulnerability).

The RMMS dataset has a file called 'traffic.htm' for each road, for different types of traffic and different chainages. This file contains a table with traffic data for Heavy Truck, Medium Truck, Small Truck, Large Bus, Medium Bus, Micro Bus, Utility vehicle, Car, Auto Rickshaw, Motorcycle, Bi-Cycle, Cycle Rickshaw, and Cart. Some data are measured, and others are estimated. The traffic is measured as AADT, which is the total volume of vehicle traffic in both directions on a section of road for a year divided by 365 days. Actual traffic in an hour can be higher – e.g., weekdays versus weekends or day versus night. Still, the AADT gives a very good indication of the importance of a road and the number of truck passages per day or year, which can be translated to the number of tonnes transported via that road per year. Furthermore, we have, of course, the location of bridges on the road and their quality, which can give insight into the vulnerability of that stretch of road in case the bridge is damaged. Use this information to configure/adapt the network model and to design the experiments and analysis in this assignment.

#### Assignments

1. Study the literature and define the vulnerability and criticality of a road/network, where vulnerability relates to the probability that roads get impassable after natural disasters (cyclones, heavy rain, flooding, mudslides, earthquakes, etc.), and criticality relates to the amount of goods transported over the road, i.e., the economic importance of a road. Provide the definition you use for vulnerability and criticality with corresponding literature references in your report, and use an operationalisation of your definition in the subsequent assignments.
2. Analyse the vulnerability and criticality of the transport network. You can do so by using the traffic data in the RMMS dataset. In addition, you can also experiment with the simulation model you created in Assignment 3.
  - a. If you choose only to analyse the RMMS dataset (and not to use the simulation model), you need to analyse traffic density per mode of transport for the main roads in the whole Bangladesh network. Specify which ones are deemed as main roads in your analysis. Provide (visually supported) insight into the **top-10** of most vulnerable as well as most critical roads or road segments and bridges for cargo transport.
  - b. If you also choose to use simulation experiments (and adapt the model accordingly) to analyse the road network for traffic density, you only need to do the analysis for N1 and N2 with their side roads (that are also N roads). Relate the results (i.e., simulation output) visually in such a way that it provides good insight into the vulnerability and criticality relation of road segments and bridges with different qualities.

We expect that you will work with Python for data visualisations. It is not required to create visualisations using a Web browser, as this might take too much time. Feel free to use any tools you are comfortable with - PyCharm, Jupyter, iPython, etc.

Note 1: For data visualisations, think carefully about whether you want to use a geographical or schematic view of criticality and vulnerability. (You may also use other credible online information if you wish.) It should be possible to run your analysis for given roads.

Note 2: Provide sufficient instructions in README so that the TAs can run the programs and replicate the results.

Note 3: For those who decide to use simulation experiments for the analysis, there is an example solution (on BrightSpace; this will be released after the submission of Assignment 3) of how to use NetworkX to represent the network structure and for shortest path computation (in case you need some hints on the implementation). You can also use your own solution for Assignment 3 if you wish. Be creative with your experimental design in this Assignment. Think about how and when you want to generate the trucks, how you want to introduce delays at bridges, which routes the trucks shall drive (the routes do not need to be random), etc. Make sense of the experimental design considering the traffic data. (You may also use other credible online information if you wish.) Do not be afraid to make assumptions as long as they are reasonable and well-documented. Think about how you measure criticality and vulnerability. Adapt the model accordingly. Ideally, the experimental design is explorative and iterative. This means you run a few experiments and get results that inform you about the next round of experiments. Describe this process in your report.

Hand in an “EPA133a-Gxx-A4” Zip file with the model and experiments (if any), data (the part you used and/or generated), the analysis programs and scripts, a selection of the generated visualisation images, and a short report in pdf including the definitions you used, literature references, your methods, your main findings, how your visualisations support the communication of the findings best and a reflection. The report should have a length of about 6-10 pages (this means 3000-5000 words), excluding images and references. Upload the Zip file to Brightspace following the Submission Guidelines.

### Time to spend and Deadline

There are 8 lab hours dedicated to completing the lab assignment. In addition, you are each expected to spend another **8 hours maximally** per person on carrying out the exercise. Don't overspend your hours and see how far you can get with the experimentation, analysis and visualization in 16 hours total. If you choose only to do data analysis, you could already get a passing mark if you define criticality and vulnerability and analyse the road network with cargo transport. Of course, this also depends on the quality of your analysis. If you choose to also use the simulation model, you could already get a passing mark if you define criticality and vulnerability; provide a meaningful design of the experiments and adapt the model accordingly. Divide the work well within your group, and make sure you use the available hours of all team members combined well, through good collaboration and communications. We expect all team members to be able to contribute equally.

The deadline for handing in the Zip file of Assignment 4 is Friday in week 8 at 18:00.

**Only upload using the Assignment function. Do not use the File Locker or email to hand in – we will base the grading on what you hand in as Assignment 4 on Brightspace.**