Advanced Discrete Simulation : Lab 3

Group 2

March 26, 2018

1 Introduction

This report reflects on the third step of "Bangladesh Relief Operations" project. The aim of this step is to visualize the findings of the data processing activities of step one in a clean, convenient and effective way. The primary target group is identified as the decision makers who are working in governmental offices related to road infrastructure. We developed a web application (https://adslab3.herokuapp.com/) to present the findings of our analysis so that decision makers and relevant stakeholders can easily access and share the results.

In the first sections, we will define vulnerability and criticality of the provided infrastructural component. Furthermore, the data processing part is briefly explained and the related assumptions are shared. In the third section, methods implemented to visualize the findings are introduced. The report is finalized with the insights that were acquired by using the visualization tools.

2 Understanding Vulnerability and Criticality

In their colloborative work; Jenelius, Petersen and Mattsson reviews the concepts that are used in vulnerability analysis of road networks Jenelius et al. (2006). In particular, they are describing the term of vulnerability by using two distinctive approaches, which are "sensitivity to threats and hazards" and "susceptibility for rare, big risks" Jenelius et al. (2006). It is stated that a network's vulnerabilities can be examined when it reaches its capacity or the infrastructure is forced extreme by external destructive factors such as natural disasters Jenelius et al. (2006). Special attention has also been paid to Berdica's definition of vulnerability which is the effect of incidents that can result in the degradation of the serviceability/reliability of road networks Jenelius et al. (2006). It can be stated that the these approach regards vulnerability as a complementary term to reliability, which is defined as the degree of ability of a traveler to estimate his/her travelling time by Immers et al Jenelius et al. (2006). When the abovementioned approaches are considered together, it can be stated that the number of bridges in each segment and the related types are affecting our road segments' vulnerability since the travel time of motorized as well as non-motorized is highly depending on it. Especially if the roads are exposed to natural disasters such as earthquakes, floods and cyclones. The definition of "road segment" is presented in the next section where the data processing activities are explained.

Ashrafi et al. points out the fact that most of the studies about road's infrastructural analysis miss the economic aspects of roads and their changing importance with respect to the monetary potential that they hold Ashrafi et al. (2017). In their study, they focus on the economic losses caused by potential disasters, and evaluates the road's conditions respectivelyAshrafi et al. (2017). Measures like the value of the goods transported, and the delay time which can be realized due to an incident are utilized in the paper. This approach highly complies with our definition of criticality that is presented in the next paragraphs. In the study of Jenelius, Petersen and Mattsson, the notion of criticality is described as a measure of the damage of the selected network component on the system, if it is out-of-service Jenelius et al. (2006). In our case, AADT data per line is used as a representation of the potential damage on a road segment.

In our case, we basically utilize the findings of literature review by considering idiosyncratic conditions of our project. The vulnerability of a road segment is identified as the product of number of bridges weighted by their coefficients which are determined with respect to the probability of a bridge to get destroyed during a disaster. The detailed information about these calculations can be found in the following sections of this report. On the other hand, the criticality of a road segment is evaluated by using the traffic data. It is assumed that the number of trucks on a road

is an indicator of the volume of economic activities on that road, while the number of non-truck vehicles can be used as an indicator of the population around this road. In the light of these assumptions, we calculate the criticality as the sum of weighted number of trucks and non-truck vehicles. Since the gap is tremendously high between frequently used roads and the roads which are placed in remote places, the criticality values are normalized between ***0 and 100***, to have a better visualization in color scales at the end. As an extension in this discussion, Bengtsson and Tómasson's report states that a link between two nodes is critical if its failure significantly affects the travel times or accessibility of the other nodes Bengtsson and Tómasson (2008). In our case, we do not consider about accessibility of the other regions by assessing the effect of a selected road segment's failure. Our focus is on the economic aspects rather than accessibility. We considered that during a disaster or some kind of a rare destructive incident, the accessibility can be improved by using air transportation such as helicopters. However, the economic aspects (especially freight transportation) are highly based on the road's conditions literature. Therefore, we considered that focus should be on the road conditions since the purpose is to present the decision makers which bridges in which segments of the roads is critical to invest. However, still further studies can be conducted to cover both aspects and yield a more comprehensive analysis of road infrastructures of Bangladesh.

3 Data Preprocessing

As a base for this assignment, cleaned road and bridge datasets from previous assignments were used. In addition, information about the traffic and road characteristics was obtained from the corresponding text and HTML files. The main goal was to create one comprehensive dataset from this scattered sources.

In order to achieve this goal, following preprocessing operations were made. At first, the multiple width text files as well as the multiple traffic htm files were combined each into one dataset. In the second step, the left and right line were summed up into one road to facilitate a more flexible data handling. Furthermore, every entry with "startChainage" and "endChainage" in the traffic dataset were defined as one segment. According to the starting and ending chainage the segments were introduced into the road dataframe and width dataframe. In the penultimate step, datasets, the equation of vulnerability and criticality were calculated and implemented into seperate columns of the traffic dataset. Finally, the dataframe were transformed into a csv-file for the visualization purpose in "app.py" .

4 Visualization

After processing the data and acquiring the results in data frames, first we identified the target group in order to visualize the data according to their prior technical knowledge and to satisfy their interest with the insights from the visualization. Accordingly, the client is identified as the decision makers of the Ministry of Planning in Bangladesh.

We assume that the result-oriented decision makers have varying technical knowledge and thus we decided to visualized our findings simple and clean by presenting just the essentials. The criticality and the vulnerability of the road segments in the road infrastructure is displayed in a web application, so that users can easily reach the results of analysis, and play with a adequate amount of inputs to reach different results. The screen shot of the web application is presented below in Figure 1.

To enrich visualized outputs, mainly "Plotly" library is used. The interactive dashboard for a greater user experience is prepared by calling "Dash"; the dynamic map view is utilized by relating "Plotly" with "Mapbox"; the web application (https://adslab3.herokuapp.com/) is created by pushing the code into Heroku platform by connecting it with the GitHub repository (https://github.com/yugdeep/adslab3). The criticality and vulnerability is visualized by not only the values, but also the sequential color palettes which was imported from "Colorlover".

Since it is difficult to describe the powerful capabilities of our visualization in few words, we created a video via ScreenCast to demonstrate our deliverable. The file is provided within the "Group02-Lab3.zip" - file. Instead, in the following we will briefly point out the advantages of our visualization method's and distinctive features in the following paragraph.

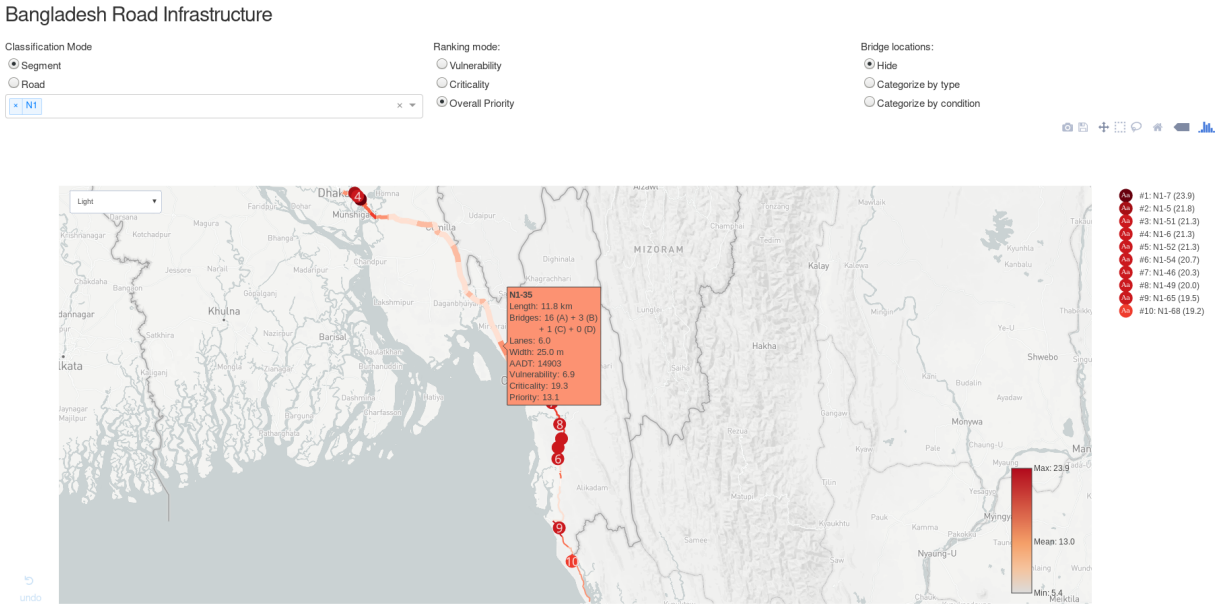

Figure 1: User-view of the application, while N1 is being examined.

First of all, it is completely dynamic. The user is able to choose not only one road or all of the roads, but customly grouped roads at the same time, and the overall vulnerability and criticality analysis among these road's segments is provided respectively. It is available to examine the road itself, or the segments separately. It is also possible to examine the roads with respect to their type, such as "National Roads", "Regional Roads", and "District Roads", which allows users to decide where to invest if there are "road type" based restrictions. Additionally, user gets additional information about the segment when they hover over it. Finally, the user can choose which measure to be displayed by choosing between criticality and vulnerability options. We provide the users with the freedom of selecting the effective factor while they are evaluating the roads to invest in to improve the overall infrastructure.

Finally, we want to elaborate on what can be done for further studies if the aim is to create a more comprehensive application, or to acquire more precise results. First of all, the library we used to visualize the findings, "Plotly", is a paid library for several capabilities while it is free-to-use for some others. This situation sometimes limited the outcomes that we wanted to achieve, or we needed to find loopholes to code and it required a lot of extra time and effort. Therefore, to create a professional application that serves as a decision-support tool, utilizing an unlimited visualization library can be considered as a requirement. Secondly, we intended to create "Bandladesh Disaster Maps" to detect the disaster-prone regions virtually and evaluate our road segments and/or bridges respectively. However, most of the data that we managed to find is on-sale by governmental offices, and the publicly available data that we could find was not in a good condition to utilize for our purposes. Therefore, this study can also be improved by adding the data about regional disasters, and evaluating the vulnerability of the network components by using this extensive data set. Lastly, as it is already stated in the second section, we did not take the position of the road segments and their influence on the accessibility of nodes (cities, villages, etc.) if they are out-of-service into account. Although our focus is determined as the economic volume in this particular assignment, a more comprehensive analysis can be conducted by including the above-mentioned aspect about accessibility.

5 Executive Summary

As was stated earlier a broad overview for decision-makers should be provided. It was done in the following way. The "Ranking mode" menu in the middle of the page consists of three radio buttons. These buttons highlight criticality, vulnerability, and overall priority (weighted sum of criticality and vulnerability) of the roads. Based on defined formulas, 10 most important roads were identified and depicted on the map with the ticks representing their ranks. Color schemes

were used to support intuitive understanding: importance increases as the color getting darker. In addition, a list of these roads and the values were deduced on the right side of the application. It is also possible, for example, to decrease a level of granularity by setting a particular segment of the road (radio button - "Segment") and highlighting the bridges (radio buttons in the menu "Bridge locations"). A user can also enter multiple road names in the provided input box to observe their conditions in the map. We believe that representing the findings in this way highlights the essential information for a decision-maker in the first glance and still encompasses comprehensive exploration capabilities. A web based visualization tool requires no technical setup by the decision makers and relevant stakeholders and was thus found to be well suited as a deployment platform.

References

Ashrafi, Z., Shahrokhi Shahraki, H., Bachmann, C., Gingerich, K., and Maoh, H. (2017). Quantifying the criticality of highway infrastructure for freight transportation. *Transportation Research Record: Journal of the Transportation Research Board*, (2610):10–18.

Bengtsson, J. and Tómasson, B. (2008). Vulnerability and risk analysis of the road infrastructure in reykjavik. *Project Number VR7RA, Vegagerðin Island*.

Jenelius, E., Petersen, T., and Mattsson, L.-G. (2006). Importance and exposure in road network vulnerability analysis. *Transportation Research Part A: Policy and Practice*, 40(7):537–560.

Appendix I

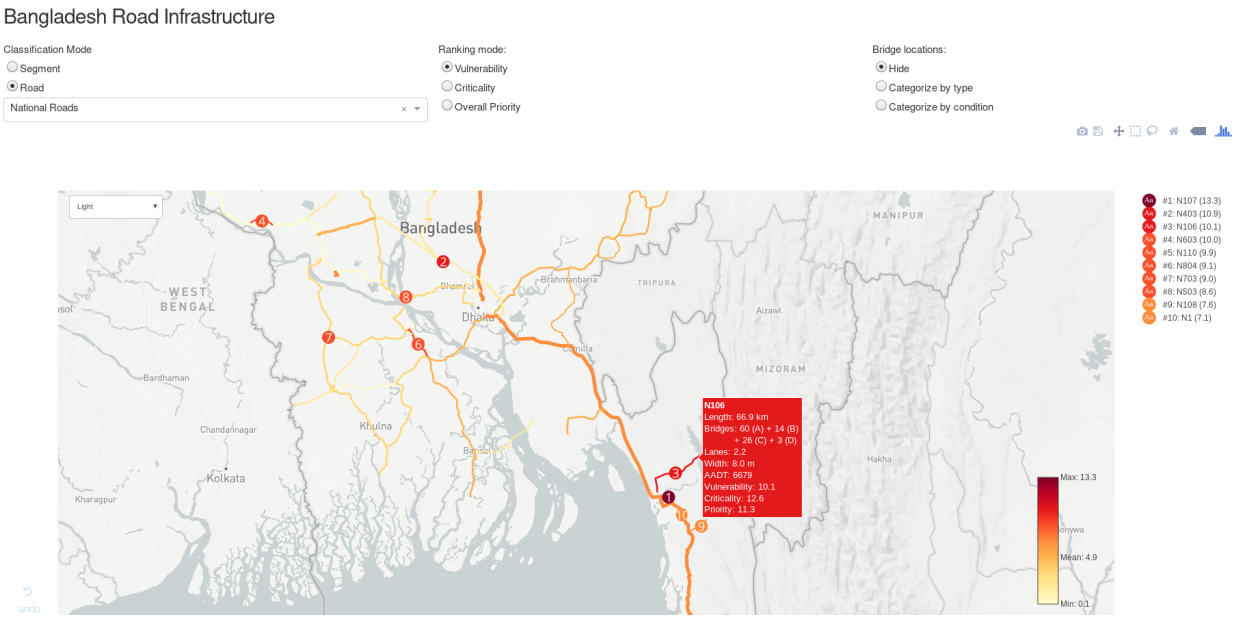

Figure 2: User-view of the application, while National Highways's vulnerability is being examined.

Appendix II

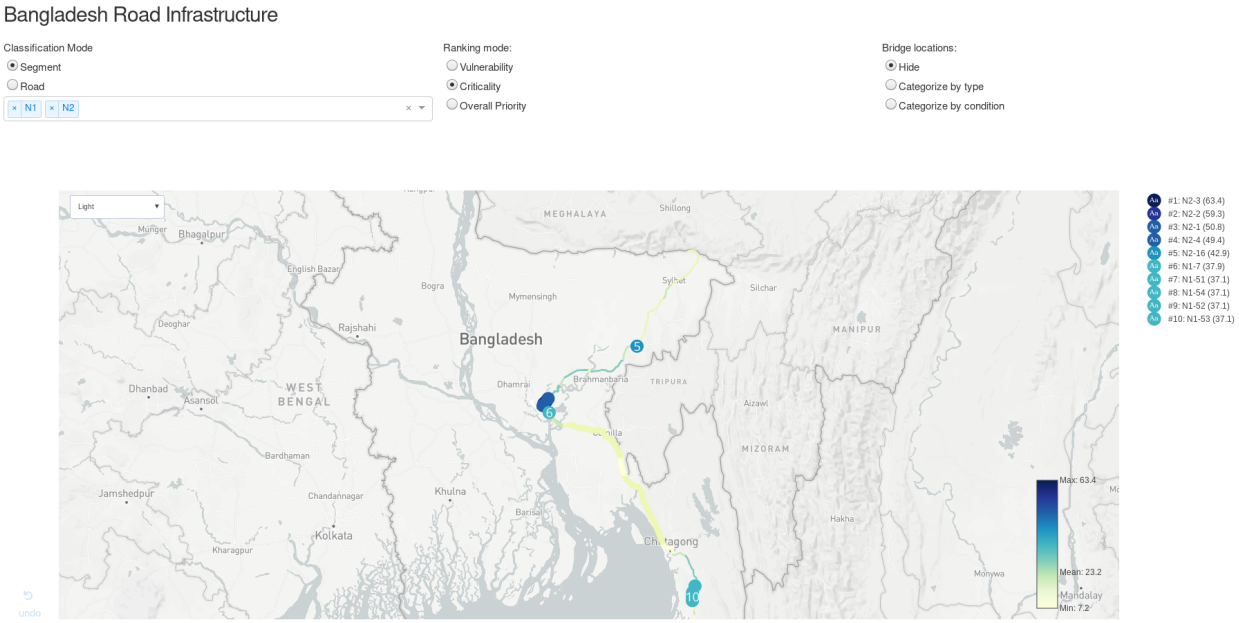

Figure 3: User-view of the application, while N1 and N2's criticality is being examined.

Appendix III

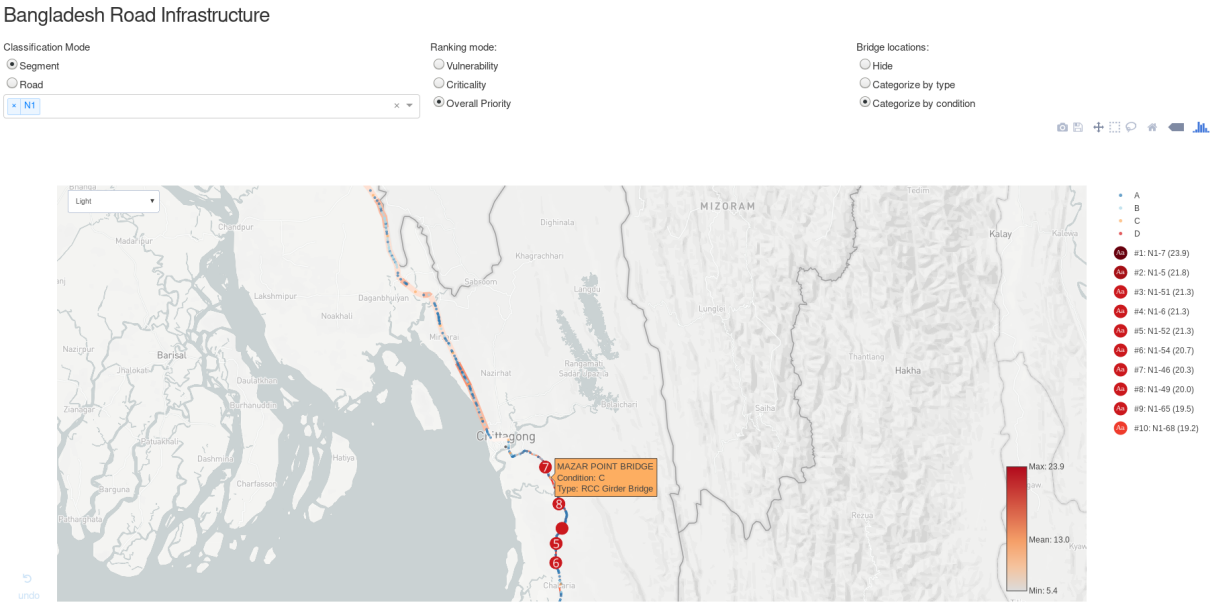

Figure 4: User-view of the application, while bridges are displayed.