Milestone 6: Sensitivity and Scenario Analysis

Fatih Kurt

6 December, 2024

Contents

1   Introduction

The purpose of this document is to perform a comprehensive sensitivity and scenario analysis for the autonomous vehicles (AV) traffic simulation model. These analyses assess the robustness of the model and its response to changes in key input parameters. This report follows the systematic approach outlined in the official course guide.

2   Definitions and Terms

2.1   Sensitivity Analysis

Sensitivity Analysis is a method to determine how the variation in the output of a model can be attributed to different variations in the inputs. It helps identify which input variables have the most influence on the output.

2.2   Scenario Analysis

Scenario Analysis is the process of evaluating possible future events by considering alternative plausible scenarios. It involves changing multiple inputs simultaneously to assess their impact on the model's outcomes.

3   Systematic Approach

3.1   Sensitivity Analysis

3.1.1   Steps

1. **Identify Key Input Parameters**

   - List all input variables.
   - Select the most critical parameters based on their expected impact.
   - Justify your selections.

2. **Define Parameter Ranges**

   - Determine realistic variation ranges (e.g., $\pm 10\%$, $\pm 20\%$).

- Use industry data or historical records to set these ranges.

3. **Design the Analysis**

   - Decide whether to vary one parameter at a time (local sensitivity) or multiple parameters simultaneously (global sensitivity).
   - Choose appropriate methods.

4. **Run Simulations**

   - Use systematic variation according to your design.
   - Ensure enough simulation runs to achieve statistical significance.

5. **Collect and Analyze Results**

   - Record outputs for each input variation.
   - Use statistical tools to interpret the data (mean, variance, confidence intervals).
   - Perform calculations to quantify sensitivity (e.g., partial derivatives, elasticity).

6. **Document Findings**

   - Create tables and graphs to visualize the impact of input changes.
   - Develop keys and legends to explain your tables.
   - Discuss the sensitivity of outputs to inputs.

3.1.2 Specific Example

Assume model output Y depends on input X. Using elasticity:

$$\text{Sensitivity} = \frac{\Delta Y/Y}{\Delta X/X}$$

An increase of X by 10% results in a proportional change in Y.

3.2　Scenario Analysis

3.2.1　Steps

1. **Define Scenarios**

   - **Baseline Scenario:** Use standard input values from initial simulations.
   - **Alternative Scenarios:** Develop at least two more scenarios (e.g., optimistic, pessimistic).

2. **Justify Scenarios**

   - Provide rationale for each scenario.
   - Link scenarios to real-world possibilities.

3. **Set Parameter Values**

   - Specify the values for all inputs in each scenario.
   - Ensure consistency and plausibility.

4. **Run Simulations**

   - Execute the model for each scenario.
   - Perform multiple runs if stochastic elements are present.

5. **Analyze and Compare Results**

   - Use comparative analysis to highlight differences.
   - Develop keys and legends for clarity.
   - Discuss the implications of each scenario.

3.2.2　Concrete Examples

Example Scenario Development:

- **Baseline Scenario:** Current market conditions with standard demand and supply levels.

- **Optimistic Scenario:** Increase in demand by 15% due to market growth.

- **Pessimistic Scenario:** Supply chain disruption causing a 20% decrease in supply.

For each scenario, adjust the input parameters accordingly and observe the impact on the model output.

4 Common Pitfalls and How to Avoid Them

4.1 Ignoring Correlations Between Parameters

- **Pitfall:** Treating parameters as independent when they are correlated.

- **Solution:** Identify and account for correlations to avoid misleading results.

4.2 Insufficient Sample Size

- **Pitfall:** Drawing conclusions from too few simulation runs.

- **Solution:** sample size recommendations.

4.3 Overcomplicating the Model

- **Pitfall:** Adding unnecessary complexity, making the model difficult to interpret.

- **Solution:** Keep the model as simple as possible while capturing essential dynamics.

4.4 Poor Data Visualization

- **Pitfall:** Using unclear or cluttered graphs and tables.

- **Solution:** follow guidelines.

5 Report Structure and Formatting

5.1 Formatting Guidelines

- Use single-column or double-column LaTeX via Overleaf.

- **Header:**

  - Include the course name, milestone title, and your name.

- **Footer:**

  - Page number aligned to the bottom-right corner.

- **Title Page:**

  - Project title.
  - Your name and student ID.
  - Course information.
  - Submission date.

- **Table of Contents:**

  - Automatically generated.

- **Sections:**

  - Use clear and consistent headings.

- **Tables and Figures:**

  - Use the `tabular` environment for tables.
  - Place large tables on dedicated pages in landscape orientation using the `pdflscape` package.
  - All tables and figures should have captions and be referenced in the text.

5.2 Content Requirements

1. **Introduction**

   - Brief overview of the milestone objectives.
   - Importance of sensitivity and scenario analyses.

2. **Definitions and Terms**

   - Clearly define all key terms.
   - Provide context and relevance.

3. **Methodology**

   - **Sensitivity Analysis Approach:**
     - Selection of parameters.
     - Variation methods.
     - Simulation execution plan.
   - **Scenario Analysis Approach:**
     - Description of scenarios.
     - Parameter settings.

4. **Results**

   - **Sensitivity Analysis Results:**
     - Tables and graphs.
     - Interpretation of data.
   - **Scenario Analysis Results:**
     - Comparative visuals.
     - Discussion of scenario impacts.

5. **Discussion**

   - Implications of findings.
   - Insights into model behavior.
   - Limitations and assumptions.

6. **Conclusion**

- Summary of key takeaways.
- Recommendations for future work.

7. **References**

- Cite all sources using a consistent citation style (IEEE recommended).

8. **Appendices**

- Supplementary material (extended data, code snippets, etc.).
- Reference terms and definitions.

6 Examples of Good vs. Poor Analysis Presentation

6.1 Good Analysis Presentation

6.2 Poor Analysis Presentation

7 Sample Size Recommendation

8 Guidelines for Data Visualization

8.1 Choosing the Right Chart Type

8.2 Design Principles

9 Presenting Data with Tables and Graphs

9.1 Constructing Tables

9.1.1 Key Components of a Table

9.1.2 Guidelines for Effective Tables

9.2 Using Keys and Legends

9.2.1 Creating a Key

9.2.2 Example of a Table with a Key

9.2.3 Explanation

9.3 Tailoring Tables to Your Simulation

10 Step-by-Step Checklist

10.1 Before You Begin

10.2 Sensitivity Analysis

10.3 Scenario Analysis

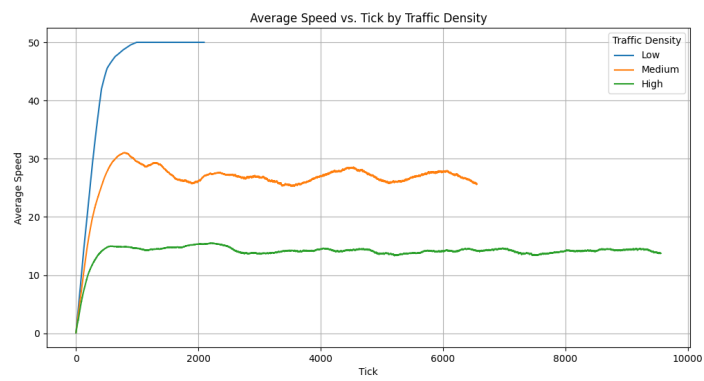### 10.4 Report Writing

10.5 Final Steps

11 Conclusion

A Visualizations

Figure 1: Average Speed vs. Tick by Traffic Density