Traffic Flow Prediction

CS-367 Artificial Intelligence
Indian Institute of Information Technology, Vadodara

Overview

Section Overview

1. Problem statement

Problem Statement

Traffic Flow Prediction: Urban traffic congestion increases travel times and fuel consumption. Current traffic management approaches are often inadequate for handling complex, dynamic traffic patterns. This project aims to develop a proactive, data-driven traffic management system using probabilistic models to predict traffic flows and congestion patterns.

Research Papers

- Kim, J., & Wang, G. (2016). Diagnosis and Prediction of Traffic Congestion on Urban Road Networks Using Bayesian Network
- Sun, S., Zhang, C., & Yu, G. (2006). A Bayesian Network Approach to Traffic Flow Forecasting
- Horvat, R., Kos, G., & Ševrović, M. (2015). Traffic Flow Modelling on the Road Network in the Cities

Expected outcome

This project develops a comprehensive approach to traffic analysis and prediction using probabilistic models. The expected outcomes include identifying key congestion causes, generating short-term traffic flow predictions, and analyzing congestion patterns.

Section Overview

2 Approach

Data Collection and Aggregation

Traffic parameters such as speed, intensity, travel time, and vehicle are utilized.

Probabilistic Graphical Modeling

This model captures the probabilistic dependencies between factors influencing traffic, such as the time of day, vehicle size, and travel time.

Traffic Forecasting

The model is used to predict traffic intensity at different intervals.

Model Integration

Integrate the trained network into a real-time traffic management system.

3 Tech Stack

Tech Stack

- **Language:** R used for statistical analysis and handling the probabilistic model.
- **Libraries/Frameworks:** bnlearn, readxl for applying probabilistic model and gathering data from databases.
- **Visualization:** Matplotlib for plotting and visualizing data, and prediction results.

4 Research Findings

Findings

- The researchers developed a Bayesian Network (BN) approach to analyze traffic congestion causes and predict congestion scenarios. They built the BN model using historical traffic, incident, and weather data from Brisbane, Australia, collected over 608 days.
- The model incorporated various factors affecting congestion (like time of day, incidents, and weather) as well as traffic performance measures (flow, density, speed). They manually specified the BN structure based on domain knowledge and validated it using scoring functions and cross-validation.
- They used quantitative methods like odds ratios and impact-probability charts to analyze the relationships between variables and identify high-risk scenarios. This approach allowed for a comprehensive, data-driven analysis of traffic congestion patterns and their causes.

Bayesian Network

- Modeling probabilistic dependencies
  - BNs encode joint probability distributions over a set of random variables that represent factors affecting traffic conditions
- Probabilistic inference
  - Once a BN model is constructed, it can perform both diagnostic and predictive reasoning.
- Scenario analysis
  - BNs can identify critical scenarios highly associated with congestion, helping traffic managers anticipate and prepare for problematic conditions.
- Capturing uncertainty
  - BNs naturally handle uncertainty in traffic predictions, providing probability distributions over predicted traffic states rather than single point estimates.

Methodology

- Data Collection and Preparation:
  - Historical traffic data from national traffic databases
  - Data aggregation to suitable time intervals
- Analysis and Inference
  - Calculate prior probabilities for various factors
  - Compute posterior probabilities to understand factor influences
  - Use Odds Ratio to identify leading causes of congestion
- Street Network Analysis
  - Analyze road network characteristics of the study areas
  - Compute various network metrics