Abstract

The logistics community in India has seen rising levels of standards and practices as small truck owners increasingly attach themselves to trucking companies, which includes usage of progressively precise GPS devices for tracking purposes. The GPS track data from trucks, collectively, have massive potential for understanding trends and patterns pertaining to truck movement. This thesis presents a collection of methods to analyse 3 key features of long-haul truck movement on National Highways of India using GPS data: (a) Segmentation of highways using speed profiles, and extending this analysis to model CO_2 emissions, (b) Identification and characterization of truck stops, (c) Modelling driving behavior in terms of drive-rest patterns of trucks.

The study begins by segmenting highways into contiguous stretches based on changes in speed profiles, leveraging the Density-Based Spatial Clustering of Applications with Noise (DBSCAN) clustering algorithm to group speed data from GPS records. This segmentation identifies distinct highway stretches where truck speeds show consistent behavior. The previous analysis is extended by modelling emissions for the highway segments from velocity readings of GPS records, using fuel consumption model, and emission factor devised for Indian conditions. The spatio-temporal trends and patterns in modelled emissions are analysed. Next, truck stops are detected using an unsupervised DBSCAN algorithm, followed by the construction of Arrival Time Distributions and Duration Distributions for each identified stop. These distributions are used to cluster truck stops into different types, revealing functional classifications of stops based on the time trucks arrive and the duration their stay. Additionally, the thesis introduces a pairwise similarity score to quantify the driving behavior of truck trips with respect to their drive-rest patterns. Using this metric, two clustering methods are applied to categorize trips into behavioral clusters: (a) Louvain Clustering, and (b) Multidimensional Scaling (MDS) combined with K-Means Clustering. These methods provide insights into the variability of driving behaviors on different highway routes.

The results of the segmentation analysis shows that infrastructural improvements, and ongoing construction work have a significant impact on truck speeds. Analysis of the truck identification and characterization work shows that truck stops can be reliably identified using GPS data, and can be characterized using truck arrival times and stop durations at the truck stops. Analysing driving behaviour shows that it has a clear impact on trip durations. Sharp rise in non-standard driving behaviour points to extreme disruptive weather events such as cyclones and cold waves. The work presented in this

thesis can aid in traffic management, logistics planning, infrastructure development, and achieving sustainability goals.

Keywords: GPS data, Highway Segmentation, Emissions Modelling, Truck stops, Driving behaviour, Similarity score, DBSCAN, Louvain method, Multidimensional Scaling