ABSTRACT

As the human population continues to grow, generating more traffic, the need for timely travel is crucial for various workplace commitments. However, this surge in activity also amplifies concerns about traffic safety, particularly related to driving behavior. Often reckless driving or the lack of skills among novice drivers contribute to accidents on the roads. As driving is a collaborative task that encompasses a multitude of factors, including the presence of peer vehicles, the duration of traffic signals, the quality of roads, etc., it is crucial to recognize that drivers cannot be exclusively held accountable for their actions. Because, these actions are often influenced by a range of external factors present in the surrounding environment. Achieving genuine road safety necessitates a comprehensive understanding and management of these variables, emphasizing the intricate interplay between them. In light of such concerns, in this thesis, we look into the problems arising due to driving behavior and how we can utilize its characteristics in enhancing the traffic safety to a next level.

First, we look into the problem of driving behavior that are often influenced by the actions of surrounding vehicles. We understand driving behavior needs treatment over different factors which compel a driver to take maneuvers that are otherwise recommended to be avoided by analyzing a large volume of publicly available data over two countries and in-house collected data. We develop a smartphone-based pervasive sensing system that utilizes video, GPS, and inertial sensor data to investigate the causes and consequences of driving maneuvers to score a driver based on a thorough understanding of their on-road driving behavior. Considering that the causality factors are very much specific to a particular driving environment (like a country), we also incorporate a domain-adaptive architecture. Over the

development, we show that a score based on such causal factors provides a more accurate representation of driving behavior.

Next, we inspect whether a sudden fluctuation in driving behavior is due to either a lack of driving skill or the effect of various on-road spatial factors such as pedestrian movements, peer vehicles' actions, etc. We understand the context behind a degraded driving behavior just-in-time to ensure on-road safety. By developing a system that exploits the information acquired from a dashboard-mounted edge-device to understand the context in terms of micro-events from a diverse set of on-road spatial factors and in-vehicle driving maneuvers taken, we see a better insights in driving behavior characterization techniques.

Consequently, we look into the opportunities in understanding the safety of individual road junctions utilizing such contextual information responsible for poor driving. Note that, current navigation systems lack detailed safety information, increasing risk for drivers and pedestrians. Thus, we develop a system that automatically annotates the road segments with a driving safety level to aid cautious maneuvering and safe driving practices. By leveraging onboard sensors, we identify the causal chains behind poor driving maneuvers, enabling the modeling of safety levels for various road segments. A thorough evaluation shows the correctness of annotating the safety concerns as well as a thorough user study indicates the generalizability and usability of the system.

Finally, we focus on individual driving behaviors and their impact on the overall traffic dynamics of a smart city. One crucial element is traffic congestion, which shapes traffic dynamics and affects commute delays and a city's overall social, economic, and environmental growth. Thus, we propose a pervasive platform that proactively infers the driving micro-behaviors that can contribute to congestion formation and assist the drivers in avoiding such maneuvers in real-time during naviga-

tion. Thorough evaluations over multiple real-life and simulated datasets indicate congestion reduction to a great extent, which is possible by avoiding anomalous maneuvers and significantly reducing the travel time of the vehicles.

In summary, we conduct a detailed study to learn the causal relation between driving behavior and the surrounding environment to infer the relevant contexts and emphasize removing bias in predicting driving behavior. This further helps us to improve traffic safety and enrich the travel experience. In a nutshell, this study provides a crucial basis for exploring city traffic dynamics, highlighting the importance of understanding how driving behavior relates to traffic management.

Keywords: driving behavior; spatial interactions; driving score; context analysis; pervasive sensing; auto-annotation; road segments; road safety; pervasive recommendation; road congestion