DEVELOPMENT OF ADVANCED DRIVER INFORMATION SYSTEM

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Pregledni članak

Abstract:

Modern passenger and driver information systems are an integral part of intelligent transport systems (ITS) and reflects the need of modern society for greater safety and efficiency. Modern approaches include proactive warning systems that detect, for example, the use of a mobile phone while driving, which represents one of the main safety challenges. In addition, driver assistance systems such as Advanced Driver Assistance Systems (ADAS) are key to supporting drivers in complex and changing road conditions. Advanced driver information systems are of great importance as they contribute not only to the safety of individual drivers but also to the efficiency of the transport network and the urban environment. In today's digital age, modern users demand sophisticated and personalized solutions that will meet their real needs and make systems more attractive, thereby increasing their use. Due to the availability of big data sets, it is now possible to achieve personalization based on behavioral biometrics, which enables a better understanding of driver behavior and the adaptation of warnings to their specific needs.

Key words: *Intelligent Transport Systems (ITS), Proactive Warning Systems, Advanced Driver Assistance Systems (ADAS), Personalization, Driver Behavior.*

INTRODUCTION

Due to urbanization, economic globalization, and the digitalization wave affecting nearly all aspects of life, including transportation, challenges arise. The influx of migrations from rural to urban areas, driven by improved living conditions and opportunities, brings a host of challenges. Projections suggest that by 2050, 68% of the world's population will live in urban areas (United Nations, 2018). Mass migrations bring their own set of challenges, especially concerning transportation.

Until 2022, transport’s CO_2 emissions were around 8 gigatonnes worldwide, which was a 3% increase from 2021. This means that the transport sector is one of the major polluters globally, with aviation and road transport playing a considerable role. For example, road transport is one of the largest polluters in this sector, where passenger cars and freight trucks are the largest contributors. These two are responsible for 74.5% of these emissions (5 Shifts to Transform Transportation Systems and Meet Climate Goals, n.d.; Cars, Planes, Trains: Where Do CO2 Emissions from Transport Come from? - Our World in Data, n.d.; Transport - Energy System - IEA, n.d.).

Besides the issue with major polluters from traffic, recent reports underscore the prevalence of road traffic accident issues both globally and within the EU. According to the global road safety report for 2023 (Global Status Report on Road Safety 2023, n.d.), there has been a slight decline in annual traffic-related fatalities to 1.19 million, but it emphasizes the ongoing need for significant improvements to halve the number of traffic fatalities and injuries by 2030.

Urban areas constantly face traffic congestion, resulting in detrimental emissions into the environment, compromised safety for all traffic participants, and a general deterioration in quality of life. As the urban population increases, so does the demand for transportation services. This poses a unique challenge in older European cities, where organizing modern transportation is a particular challenge due to narrow streets, roads, and the overall structure of such urban environments. In addition to the ongoing changes affecting cities, it is worth noting that this transformation has also influenced changes in people's needs and demands. Indeed, the lifestyle and dynamics of urban residents have significantly changed. Accessible, reliable, available, and environmentally sustainable transportation (Andrade et al., 2023) is now a necessity for most residents and an imperative for city authorities.

As previously mentioned, the accumulation of traffic issues, especially in urban areas, has naturally led to the need for Intelligent Transport Systems (ITS) to address these challenges. ITS is defined as "a holistic, managerial, and information-communication (cybernetic) upgrade of the classical traffic and transportation system, which achieves significant performance improvements. Traffic flow, more efficient passenger and freight transport, improved traffic safety, passenger comfort and protection, reduced environmental pollution, etc." (Bošnjak, 2006)

One of the consequences of building additional transportation infrastructure (build only approach) is the induction of additional traffic. However, a modern approach that encompasses infrastructure and ITS (commonly known as build + ITS approach) contributes to more efficient utilization of existing resources, optimization of traffic flows and reduction of the need for new infrastructure projects. Consequently, the integration of ITS with existing infrastructure enables better traffic management, improvement of traffic safety, increased capacity to respond to growing user demands and mitigation of negative environmental impacts.

One of the key aspects of ITS is the intelligent information systems for passengers and drivers. Accurate and relevant information is very important for passengers and drivers, especially before planning a trip, but also in finding alternative routes in case of emergencies in the traffic network. By implementing these information services, the attractiveness of public transport is increased, as well as comfort and safety (timely driver reaction). Furthermore, pertinent, and real-time information could help reduce traffic volume and associated costs by lowering fuel consumption and decreasing travel time for drivers to reach their destinations (Hassn et al., 2016). In the broader context of driver assistance, it is important to consider Advanced Driver-Assistance Systems (ADAS). Advanced Driver-Assistance Systems (ADAS) enhance safety and comfort by integrating technologies such as “adaptive cruise control (ACC), lane departure warning systems, forward collision warning systems, traffic signal recognition system (TSR), tire pressure monitoring system (TMPS), night vision, pedestrian detection, parking assistance systems, automatic emergency brake systems, driver behaviour monitoring, etc.” (Antony & Whenish, 2021)

This article is structured into four chapters, with the introductory chapter providing an overview of the issues at hand. The chapter introduces fundamental concepts that will be discussed in subsequent chapters, thereby establishing a foundation for understanding key concepts (the need for advanced passenger and driver information systems) and research objectives. In the second chapter, titled “Theoretical Framework”, fundamental terms in the field of intelligent information systems (for passengers and drivers) are defined and clarified. In the third chapter, “Application of Advanced Driver Information Systems and Personalization”, the application of driver information systems is described. As an example of a modern driver information system, the paper presents a proposal for a proactive warning system upon detection of mobile devices during driving by the driver. Special attention is given to the application of preference detection theory for the development of personalized systems of this kind. In the fourth chapter, concluding considerations and guidelines for further research are presented.

1. Theoretical Framework

The number of vehicles is continuously increasing, which, especially in urban environments, has resulted in traffic congestion, an increased number of traffic accidents, and negative impacts on the environment. In this context, there has emerged a need for assistance and support before and during travel, all aimed at addressing the challenges brought by increased motorization.

The development of Advanced Passenger and Driver Information Systems (APDIS) arises from the need for more efficient, safer and sustainable transport in today's urban environments. With the growth of urbanization and globalization, cities are confronted with challenges such as traffic congestion, harmful gas emissions, and increased demand for transportation. In such an environment, the development of APDIS becomes crucial to support the integrity of transport networks and improve the experience of drivers and passengers.

The international standardization of Intelligent Transport Systems (ITS) services provides a framework for understanding the functional areas of APDIS. One of these functional areas is Traveller Information, which encompasses various services intended to provide relevant information to drivers and passengers. The services within this functional area are based on static and dynamic information. Within this functional area are various services, including Pre-trip Information (Multimodal Journey Planners – MJPs), On-trip Driver Information, On-trip Public

Transport Information, Personal Information Services, Route Guidance and Navigation, and Transport Planning Support. Each of these services plays an important role in providing timely and relevant information to traffic users during their journeys (Bošnjak, 2006). In Table 1, detailed descriptions of various services within the traveller information functional area are presented, offering comprehensive insights into the functionalities and features designed to assist travellers and drivers throughout their journeys.

Table 1.

ITS Service	Description
Pre-trip information	It enables users to access pre-travel information from any location; available modes of transportation, travel prices for different travel methods, route suggestions, travel time information for each segment of the multimodal route (trip leg), alternative routes in case of emergencies. The emphasis is on multimodal travel information, facilitating the implementation of multimodal journey planners.
On-trip Driver Information (ODI)	It provides drivers with real-time information during travel, such as estimated travel times (based on current conditions), available parking spaces (in garages and open parking lots), speed limits, alternative routes, road conditions, accidents and incidents, special events, points of interest (POI), etc.
On-trip Public Transport Information	Providing passengers with relevant information about public transportation during their journey, including schedules, stops, delays, route changes, and points of interconnection (refraction points) of multiple modes of transportation (multimodal nodes).
Personal Information Services	Providing personalized information to passengers and drivers based on their preferences and behavior (behavior history) adds value for the individual user, as well as enhances understanding of passenger and driver behavior. Today, this approach is being increasingly integrated into a growing number of pre-trip and on-trip information services.
Route Guidance and Navigation	Navigation instructions for passengers and drivers to navigate to their destination, including the fastest or shortest routes, avoidance of traffic congestion, and alternative routes.
Transport Planning Support	Providing information and tools for trip planning to passengers and drivers, including details about available transportation modes, prices, parking facilities, and integrated travel tickets. Multimodal Journey Planners perform this service, offering passengers various relevant information for their journey from point A to point B in one place.

Source:(Bošnjak, 2006; Pagani et al., 2017; Skorput et al., 2015)

In addition to travel information, which is crucial for making decisions before and during a trip, assistive systems also serve as a significant source of information for drivers. Advanced driver-assistance systems (ADAS) are technological components that enhance vehicle safety and focused on increasing safety in traffic for both drivers and pedestrians. The set of activities performed by a driver, primarily referring to vehicle maneuvering, is supported by ADAS, which informs the driver about crucial elements during driving through warnings and information. These pieces of information reduce the driver's cognitive load, thereby enhancing driving comfort. The support system encompasses primary driving tasks and provides active assistance, for example: Adaptive Cruise Control (ACC) and automatic emergency braking systems, forward collision warning systems and blind spot detection, Tire Pressure Monitoring System (TPMS) and Electronic Stability Control (ESC), Automotive navigation systems and Traffic Sign Recognition (TSR), night vision and pedestrian detection, driver drowsiness detection and alcohol interlock systems. In this context, such information (warnings) proves to be exceptionally effective. The complex processing of signals and information within the system enables a better understanding of the information communicated to the driver when addressing common safety-critical situations. However, despite the advantages, numerous researchers point to their limitations concerning driver behavior (Brookhuis et al., 2001; Hungund et al., 2021; Starkey & Charlton, 2020). Any interactive system that delivers information through warning messages can lead to potentially dangerous situations when the driver's attention is excessively redirected from the road to the system (over-reliance on the system). For this reason, when designing such a system, it is crucial to consider how warnings or information about imminent dangers will be presented to the client, i.e., the driver. Information can be offered to the client in the following ways – visual (text message), auditory (sound signal), or tactile (seat vibration). The use of such support systems should not become an overused (uncritical) habit, nor should it be the sole authoritative information that a driver relies on during driving. In any case, 'smart' use of this system significantly enhances the level of safety and comfort of driving.

2. Application of Advanced Driver Information Systems and Personalization

Improving traffic safety stands as a cornerstone of ITS, alongside initiatives tied to the notion of smart cities and sustainable environments. However, modern travellers, or drivers, have significantly higher demands when it comes to travel and driving experiences. The ITS service *On-trip Driver Information* is one of the groups of Travel Information services, and Travel information to the driver today refers to:

- Dynamic information on traffic conditions, including road conditions, congestions, roadworks and accidents.
- Active monitoring and warnings about traffic signs, speed limits and other regulatory aspects on the current road.
- Meteorological information about weather conditions that may affect driving, such as precipitation, snow, or reduced visibility.
- Alternative routes and modes at their points of intersection.
- Information about available parking spaces, including capacity, prices, and availability, so that drivers can plan their arrival in urban centers.
- Alternative routes and recommendations for drivers, considering current traffic conditions and possible delays (in order to optimize the journey).
- Notifications about events such as sporting events, concerts that may affect traffic flow.
- Recommendations for safe and efficient driving management in accordance with current traffic conditions and road situations.

In addition, drivers find parking spaces particularly challenging in traffic (especially in urban settings). Informing drivers about available parking spaces and routes to those spaces, as well as providing guidance at parking lots/garages. The smart parking assist system begins by forecasting parking availability at the journey's start, updating these estimates as the destination approaches. In this regard, smart parking assist system includes the following according to (Ćelić et al., 2024):

- Information about P&R systems
- Real-time traffic congestion assessment on the proposed route
- Road condition – road works, closed lanes, or other obstacles
- Weather condition
- Estimated Time of Arrival
- Alternative routes in case of congestions or any obstacle
- Low Emissions Zone
- Parking pricing – current information about the parking prices on the different location
- Parking space availability-the number of free spaces in specific garages or parking lots

Furthermore, in such intelligent driver information systems, assistance and guidance within the parking lot or garage are provided. The available information includes: real-time availability of parking spaces : It implies dynamic updates on the locations of the free parking places within the parking/garage lot, Reservation (reserving parking space via the app), parking space size (information about the size of a parking place and its type - for small cars, parking places designated for physically disabled people, digital signposts (simple to understand what to do next in the parking lot - whether to drive straight or sideways or exit), information and placements of security cameras, access points (stairway, elevator, way to exit), e-charging stations (location and availability), etc.

Such information services provide relevant, real-time data that can be greatly beneficial to drivers in today's complex road conditions. These systems play a significant role in enhancing road safety, increasing driving comfort, promoting efficiency (by reducing time spent in traffic), minimizing negative environmental impacts (route optimizations contribute to reducing harmful emissions), and enhancing the overall driving experience (user experience).

Contemporary implementations of driver information systems are now driver-oriented. In addition to enhancing traffic safety, modern users demand comfort and a high-quality driving experience (e.g., personalization). Personalization refers to customizing the driver information system to individual preferences, behaviors, and needs of the driver. This includes everything from the way information is displayed, to the types of alerts and how these systems respond to specific driving situations. Personalizing driver information systems enables tailored and relevant information for each driver, which can result in numerous benefits, such as receiving information customized to end-user preferences, leading to more comfortable journeys, including points-of-interest information (especially important for tourism), reducing stress during driving, facilitating easier and more efficient trip planning and reducing uncertainties.

In this regard, modern driver information systems integrate the selection of personalized information and methods based on the analysis of previous historical passenger data. Incorporating personalized travel information is an essential element of modern ITS. Passengers can access real-time information concerning traffic conditions, road maintenance and construction, transportation services, ride-sharing/carpooling, parking management, tours, and pricing details. Given that these systems retain a vast array of driver data, including driving characteristics such as aggressiveness, semi-aggressiveness, passivity, and reaction time, among others, this historical data can be leveraged to bolster collision warnings and other driver assistance functionalities (Ioannou & Zhang, 2016).

3. Proactive Warning Systems for Risk-Prone Driving Behaviors

In the previous chapters, the importance of developing and implementing driver information systems has been emphasized. Given the complex environment of the transportation network, the provision of informational assistance is crucial. Such assistance can facilitate travel, enhance safety and comfort, and, by optimizing routes based on environmentally friendly preferences, reduce harmful emissions. This leads to an improved user experience. These systems can be implemented both in-vehicle and through mobile phone applications.

Today, advanced driver information systems can also detect risk-prone driver behaviors, such as speeding (driving above the speed limit or driving too fast for the conditions), distracted driving (any activity that removes the driver’s focus from the road, including *cell phone use*, eating, or interaction with in-car technologies), driving under the influence, in other words operating a vehicle while legally impaired from the use of alcohol or drugs, fatigue driving (extremly tired driving), non-compliance with traffic signals (not stopping atr traffic lights, stop signs, etc.), improper use of lanes (not staying in the right lane or not safely changing lanes), etc.

In this context, particular attention should be directed towards analyzing driver behavior in relation to compliance with speed limits and adherence to other traffic directives. This represents a fundamental condition for the successful application of this method in highway safety management. In the recent period, advanced technologies enable the use of operational data from mobile networks for the analysis and detection of traffic flow characteristics. As illustrated in Figure 1, data sources from the telecommunications sector can be applied for various analyzes related to road traffic. Information such as signaling data, CDR data and user dana (subscriber data) can be used for both strategic and operational purposes, such as identifying traffic flow characteristics (such as traffic volume and speed), analyzing cases of distracted driving (for example, *analyzing mobile phone use by the driver*), and identification of the demand for transportation (data on departure and destination points).

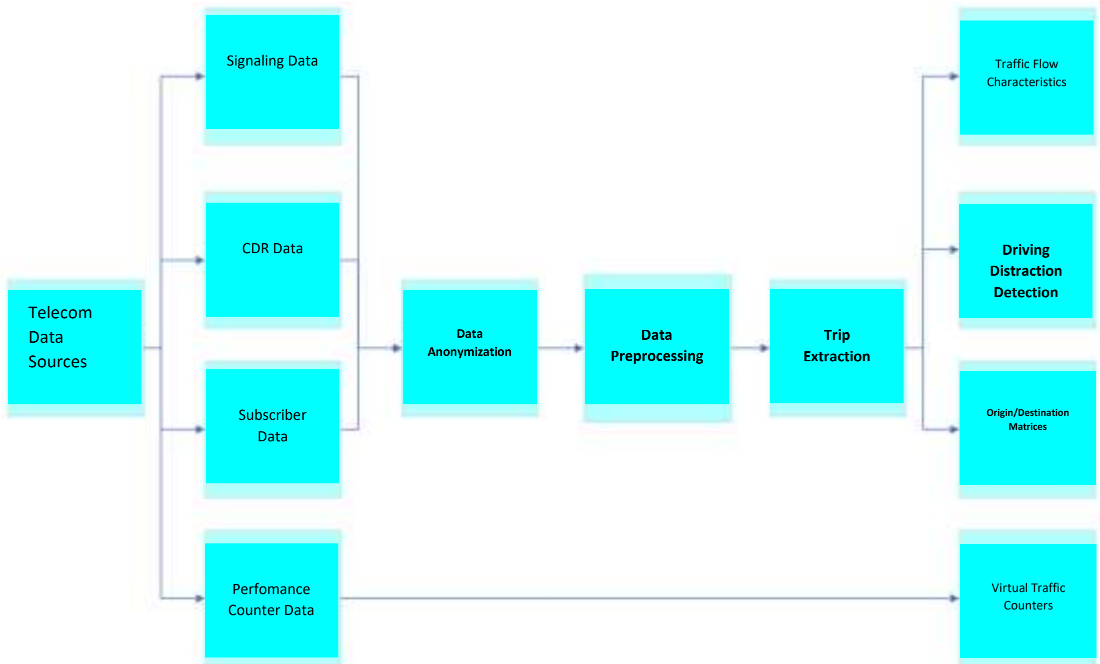

Figure 1. Framework for Utilizing Data from Mobile Networks

Performance data can be used to create highly efficient virtual traffic counters, complementing existing locations where traditional counters are not available. Additionally, this technology enables the development of advanced systems for proactively informing drivers. Such systems include highway information systems, such as variable traffic messages, and more recently cooperative systems based on infrastructure-to-vehicle (I2C) communication.

4. Conclusion Remarks

Traveling in urban environments today is both complex and dynamic. Implementing Intelligent Transport Systems (ITS) is crucial for ensuring traffic is efficient, safe, and environmentally friendly in cities, thereby enhancing the overall travel experience for users. Recently, systems that provide timely information to passengers and drivers have proven especially relevant. These systems play a key role in alleviating the often uncomfortable, stressful, and tiring aspects of urban travel, and in reducing traffic loads on city networks. Delivering relevant and real-time information through in-vehicle or mobile interfaces, tailored to the actual needs of users, aids in route optimization. This includes selecting routes that minimize waiting times and fuel consumption, thereby reducing congestion and emissions of harmful pollutants. Support systems, such as Advanced Driver Assistance Systems (ADAS), are also crucial. They enhance safety, enjoyment, and seamlessness of driving by offering a suite of functionalities. Moreover, advanced in-vehicle information systems are equipped with features to detect risky driving behaviors. These systems can identify various risky conditions, including speeding, aggressive driving, non-adherence to speed limits, driving under the influence of alcohol, and mobile phone use while driving. Along with static and dynamic traffic signals from the environment, these systems are fundamental to road safety management. Future research should aim at personalizing these systems to identify specific driving behaviors and other behavioral elements that truly meet the real needs of users. This data will also serve as the foundation for future generations of advanced information systems.

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