**Chapter 3. ITS and related applications**

**3.1 Intelligent transportation systems in big data**

Intelligent Transportation Systems (I.T.S.) uses information and communication technologies in transportation. The evolution of ITS is still ongoing. Thereby, the extent to which these technologies are used – and the sophistication with which they are deployed – varies by country. ITS's key theme is the integrated deployment of information networks to support travel, increase transportation infrastructure use, and better manage demand. Intelligent Transportation Systems (ITS) are information and control systems that use data processing and integrated communications technologies to accomplish the following tasks:

* enhancing people and goods mobility
* improving safety, reducing traffic congestion, and effectively managing incidents
* achieving transportation policy objectives and goals, including demand management and public transportation priority measures

The definition encompasses a wide range of techniques and approaches that can be accomplished through stand-alone technological applications or integrating various systems to provide new (or improved) transportation services. ITS provides the tools to enhance safety and transform mobility, and it is crucial in the context of road network operations. Intelligent transportation systems (ITS) include cutting-edge wireless, electronic, and automated technologies. These technologies, when combined, have the potential to integrate vehicles (public transportation, trucks, and personal vehicles), system users, and infrastructure (roads and transit). Automated guideways, precision docking for buses, and collision avoidance systems are examples of automated and in-vehicle technologies. Many ITS technologies can aid in trip optimization (route guidance), reducing unnecessary miles travelled, increasing other mode use, reducing time spent in traffic, reducing reliance on foreign oil, and improving air quality. Furthermore, when applied to system management (transit and highways) and vehicle design, ITS technologies can reduce fuel consumption by:

* enabling pricing and demand management strategies;
* facilitating optimal route planning and timing;
* increasing the appeal of using public transportation;
* smoothing accelerations/decelerations and stop-and-go driving;
* reducing congestion;
* allowing for small platoons of closely spaced vehicles (Weight reduction may be possible with safer vehicles without jeopardizing occupant safety);
* Modifying vehicle transmission to account for changing road conditions and terrain;

Many ITS applications play a role in efficient road network operations, with the following goals in mind:

* maximizing the capacity of the existing road network
* ensuring that the road network runs as efficiently, safely, and sustainably as possible

The most commonly adopted ITS applications aim to improve road networks' efficiency, safety, and sustainability. For example:

* systems for managing travel demand and traffic – such as incident management, traffic control, travel demand management, electronic payment, parking management and control
* traveller information system applications that enable road users to make informed travel decisions, such as route guidance and driver information
* The concept of connected self-driving vehicles is becoming more feasible and well-known, which will have significant implications for road network operations, requiring careful consideration.

**3.2 Applications and related projects**

Detailed transportation data can now be accessed and shared at unprecedented scales, revealing new transportation paradigms and opportunities related to smart mobility. The Big Data paradigm fosters a plethora of application areas in the transportation and mobility domain, involving some – or all – of the critical stakeholders in their application scenarios: citizens (pedestrians and road users), the public sector (governments and authorities), and private sector. The inclusion of the Big Data paradigm in transportation applications and users does not significantly differ from traditional application scenarios based on data capture, analysis, and exploitation. However, suppose the methodology and technological approaches used in such applications change. In that case, the participation of each stakeholder may span the entire Big Data cycle, from data collection to knowledge inference from the captured data.

After establishing that the data phenomenon is not radically new but relatively incremental in transportation and mobility, we develop a classification of recent Big Data paradigm applications, which are sorted based on the traditional ITS scenarios to which each of such new applications is related. They can be seen in Table 3.2.1.

**Big Data schemes in social transportation systems:**

Big data for social transportation provides us with unprecedented opportunities to solve transportation problems that traditional approaches are incapable of solving and build next-generation intelligent transportation systems. However, even though social data has been used for transportation analysis, many challenges exist. First, social data evolve and contain a wealth of information, necessitating the collection and cleaning of data. Meanwhile, each type of data has distinct advantages and disadvantages for social transportation, and no single data type can adequately describe the overall state of a transportation system. Therefore, systematic data fusing approaches or frameworks are required for combining social signal data with varying features, structures, resolutions, and precision. Second, data processing and mining techniques such as natural language processing and streaming data analysis necessitate further revolutions in effectively using real-time traffic information. Third, social data is linked to cyber and physical spaces [20].

**Methodology for collecting naturalistic observation data of pedestrian and driver interactions**

The increasing use and impact of information technology can endanger pedestrians more than ever; nevertheless, the scope to which pedestrian safety is affected as a result of driver and pedestrian distraction is not well established. The National Highway Traffic Safety Administration's ongoing project, Effect of Electronic Device Use on Pedestrian Safety, aims to quantify the risk of pedestrian crashes caused by electronic devices by both drivers and pedestrians. To assess the influence of distraction on crash risk, high-quality data on the pervasiveness of interruption among drivers and pedestrians is required. In addition, to investigate the role of pedestrian and driver distraction in crash frequency and severity, valid surrogate steps of traffic conflict and state pedestrian crash data are required. A robust field data collection method collected pedestrian-vehicle conflicts, distractors, and safety-related behaviours [21].

**3.3 Open challenges**

The extensive activity evident in the previous sections' literature review is a clear indicator of the recent technological advances with Big Data applied to the transportation and mobility domains. However, not only do several open research issues remain unresolved and unaddressed, but new challenges emerge as a result of data exchange and exploitation across heterogeneous transportation areas. Several research niches are enumerated and argued about concerning the noted contributions in the last year and postulated what associated problems should be resolved under new Big Data functionalities.

**New data sources**

Section 2.2 previously described new data sources emerging in the transportation and mobility landscape that unleash new possibilities, services, and applications, owing to the increased density and heterogeneity of sensors deployed in urban scenarios (e.g. high-definition vehicle speed detectors, pedestrian counting devices and vehicular LIDAR radars for obstacle identification). However, this variety of new data sources brings with it new problems to solve in terms of volume and coverage, variety, value or purpose, and quality, as detailed below:

* Data volume and coverage: today's transportation datasets are much larger than before. Although specific safety applications do not require high data volumes to be captured (for example, blind-spot warning), other services and applications on board are expected to go beyond the rate limits imposed by current communication standards such as DSRC, such as high-resolution proximity mapping with LIDAR radar sensors. This augmented information generated by vehicles implies that traditional data-handling technologies and processes do not work in practice, necessitating a rethinking and redesign of ITS to accommodate such volumes of captured data.
* Data variety is the complexity of multiple data sources contributing to a rising tide of different formats, temporal resolutions, and levels of accuracy. Underlying the variety of transportation data is the challenge of combining, fusing, or integrating it for later analysis or representation. Data fusion, for example, is a critical processing step for ITS areas and use cases that include heterogeneous sensors and information sources, such as ramp metering, pedestrian crossing, automatic incident detection, travel time prediction, adaptive signal control, and crash analysis and prevention. In this regard, the survey in [26] identifies future research needs. The next step after data fusion is information fusion, which determines how decisions are made based on results from multiple data sources. Optimization algorithms, for example, can be an efficient option for determining how to fuse and aggregate the captured information streams optimally. For example, the case of Hernández de la Iglesia et al. work's in [27] proposes an intelligent engine management system for e-bikes that uses sensor data to optimize battery energy and time. Based on the data, the collected information is analyzed and merged so that the framework can provide the client with ideal and personalized assistance.
* Data value or purpose: In general, it is not only the amount of data that matters in the Big Data life cycle but also its intelligent use in confirming or validating a hypothesis. This statement is also true for the transportation domain, but with the added disadvantage of a potentially costly data collection process (mainly when physical sensors are deployed along with the infrastructure) [28].
* Data quality refers to the data's completeness, homogeneity, and trustworthiness. Quality and accuracy are less controllable in many forms of Big Data, as large data volumes frequently compensate for lack of quality or accuracy. Furthermore, the requirements for accuracy, cleansing, and certainty vary depending on the data-based application at hand: accidents, for example, require as much accuracy and reliability as possible for the processed data, whereas other user services, such as predictive rerouting, do not. A critical challenge is providing standardized methods for quantifying the reliability and quality of data at both the collection and retrieval stages and tracing and measuring their impact on the knowledge inferred in the upper layers of the processing stack.