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Intelligent transport systems — Big data and artificial intelligence supporting intelligent transport systems — Use cases

Systèmes de transport intelligents - Données massives et intelligence artificielle à l'appui des systèmes de transport intelligents - Cas d'usage

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Contents

Foreword

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This document was prepared by Technical Committee ISO/TC 204, *Intelligent transport systems*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The term "big data" refers to extensive datasets that require specialized technologies and techniques for their processing and realization of value due to their characteristics in terms of volume, variety, velocity and variability (see ISO/IEC 22989 and ISO/IEC 20546).

Technologies have been developed specifically to enable the distributed processing of large datasets using clusters of computers while using simple programming models. Additionally, storage and database technologies have been developed specifically to manage and organize large volumes of data, even when composed of multiple large datasets.

As defined in ISO/IEC 22989 and ISO/IEC 23053, artificial intelligence (AI) systems, in general, are engineered systems that generate outputs such as content, forecasts, recommendations or decisions for a given set of human-defined objectives.

AI covers a wide range of technologies that reflect different approaches for dealing with these complex objects. Big data has many uses within the context of AI systems, and it is an enabler of many such systems, in particular for machine learning (ML) and deep learning (DL).

This document focuses on use cases specific to intelligent transport systems that take advantage of big data technologies and AI techniques.

NOTE 1 ISO/IEC 22989 raises the issue of using terms such as “intelligent”, “intelligence” and “artificial intelligence”, which can anthropomorphize AI systems. The use of these terms can be misleading.

NOTE 2 Much of the content of this document originates from other ISO/IEC standards, as well as reports produced by a wide variety of entities with ties to AI, ML and transportation. For references to documents attributed to the United States Department of Transportation (USDOT), permission has been granted to use content as shown herein. For all other cases, content is referenced by quotes and paraphrases are avoided, with readers encouraged to seek out the referenced sources for more detailed information.

NOTE 3 The contents of this document are closely tied to the provider’s intellectual property. Experts in AI and big data can derive specific models based on data types, required confidence, tolerances and combinations. Use cases are for informational purposes only.

Intelligent transport systems — Big data and artificial intelligence supporting intelligent transport systems — Use cases

1 Scope

This document provides a collection of use cases specific to the domain of intelligent transport systems that take advantage of big data technologies and artificial intelligence (AI) techniques.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
artificial intelligence
AI
<discipline> research and development of mechanisms and applications of *artificial intelligence systems* (3.5)

Note 1 to entry: Research and development can take place across any number of fields such as computer science, data science, humanities, mathematics and natural sciences.

[SOURCE: ISO/IEC 22989:2022, 3.1.3]

3.2
artificial intelligence algorithm
AI algorithm
<intelligent transport system> sequence of *artificial intelligence* (3.1) related operations for performing a specific task

Note 1 to entry: Rule-based algorithms use inputs and parameters, which are generally determined based on expert knowledge, to determine outputs.

Note 2 to entry: Machine learning algorithms use example inputs and outputs (if available) to determine model parameters.

Note 3 to entry: Rule-based and machine learning-based algorithms differ in how they are created or trained.

3.3
artificial intelligence application
AI application
<intelligent transport system> software application with *artificial intelligence* (3.1) related functional characteristics that operates in a context with its stakeholders' interrelated activities to deliver an intended result

Note 1 to entry: The term "application" is generally used when referring to a component of software that can be executed. It consists of one or more components, modules or subsystems.

3.4
artificial intelligence method
AI method
<intelligent transport system> *artificial intelligence* (3.1) related problem-solving process

Note 1 to entry: The term "process" refers to a set of interrelated or interacting activities that transforms inputs into outputs.

Note 2 to entry: Machine learning (ML) methods can be classified into three approaches: supervised ML, unsupervised ML, and reinforcement ML.

Note 3 to entry: Conventional computing methods are generally applied to find precise and rigorous solutions to problems.

EXAMPLE ML employs a set of statistical methods to find patterns in existing data and to then use patterns to make predictions on production data.

3.5
artificial intelligence system
AI system

engineered system that generates outputs such as content, forecasts, recommendations or decisions for a given set of human-defined objectives

Note 1 to entry: The engineered system can use various techniques and approaches related to *"artificial intelligence"* (3.1) to develop a model to represent data, knowledge, processes, etc., which can be used to conduct tasks.

Note 2 to entry: AI systems are designed to operate with varying levels of automation.

[SOURCE: ISO/IEC 22989:2022, 3.1.4]

3.6
artificial intelligence technique
AI technique
<intelligent transport system> set of *artificial intelligence* (3.1) related methods, tools and skills required to carry out a specific activity

Note 1 to entry: AI techniques include knowledge discovery and pattern recognition.

3.7
big data
extensive datasets – primarily in the data characteristics of volume, variety, velocity, and/or variability – that require a scalable technology for efficient storage, manipulation, management, and analysis

Note 1 to entry: Big data is commonly used in many different ways, for example as the name of the scalable technology used to handle big data extensive datasets.

[SOURCE: ISO/IEC 20546:2019, 3.1.2]

38
availability
property of being accessible and usable on demand by an authorized entity

[SOURCE: ISO/IEC 27000:2018, 3.7]

3.9
big data application
<intelligent transport system> software application with *big data* (3.7) related functional characteristics that operates in a context with its stakeholders' interrelated activities to deliver an intended result

Note 1 to entry: The term "application" is generally used when referring to a component of software that can be executed. It consists of one or more components, modules or subsystems.

3.10
big data technology
<intelligent transport system> platform, tool or software component used to capture, process, analyse and visualize potentially large datasets in a reasonable timeframe

3.11
computer vision
capability of a functional unit to acquire, process and interpret data representing images or video

Note 1 to entry: Computer vision involves the use of sensors to create a digital image of a visual scene. This can include images, such as images that capture wavelengths beyond those of visible light, such as infrared imaging.

[SOURCE: ISO/IEC 22989:2022, 3.7.1]

3.12
deep learning
DL
<artificial intelligence> approach to creating rich hierarchical representations through the training of neural networks with many hidden layers

Note 1 to entry: DL is a subset of machine learning (ML).

[SOURCE: ISO/IEC 22989:2022, 3.4.4, modified — admitted term "deep neural network learning" has been removed.]

3.13
reliability
property of having consistent intended behaviour and results

[SOURCE: ISO/IEC 27000:2018, 3.55, modified — the word "having" has been added to the definition.]

3.14
resilience
ability of a system to recover operational condition quickly following an incident

[SOURCE: ISO/IEC 22989:2022, 3.5.10]

3.15
robustness
ability of a system to maintain its level of performance under any circumstances

[SOURCE: ISO/IEC 22989:2022, 3.5.12]

3.16
safe system approach
<road safety> body of knowledge and practice that stems from the principle that there is no acceptable level of death or serious injury on the roads

3.17
spectrum of risk
<intelligent transport system> degree to which risk varies

3.18
trustworthiness
ability to meet stakeholder expectations in a *verifiable* (3.19) way

[SOURCE: ISO/IEC 22989:2022, 3.5.16, modified — Notes 1 – 3 to entry have been removed.]

3.19
verifiable
can be checked for correctness by a person or tool

[SOURCE: ISO/IEC/IEEE 15289:2019, 3.1.29]

4 Abbreviated terms

ADAS	advanced driver assistance system
ADB	automated driving bus
ADS	automated driving system
AI	artificial intelligence
AMQP	Advanced Message Queuing Protocol
ANN	artificial neural network
ASIL	automotive safety integrity level
ATSPM	automated traffic signal performance measure
BSM	basic safety message
CCTV	closed-circuit television
CPM	Collective Perception Message
DDT	dynamic driving task
DL	deep learning
DSS	Decision Support Systems
E/E/PE	electrical/electronic/programmable electronic
EEM	emergency event message
EUC	equipment under control
GNSS	global navigation satellite system
GUI	graphical user interface
HARA	hazard analysis and risk assessment
HAZMAT	hazardous materials
IMU	inertial measurement unit
IOO	infrastructure owner/operators
IoT	internet of things

ISMS	Information Security Management Systems
IT	information technology
ITS	intelligent transport system
KPI	key performance indicator
LTE	long term evolution
MEC	mobile edge computing
METR	management of electronic traffic regulations
ML	machine learning
MNO	mobile network operator
MQTT	Message Queue Telemetry Transport
NLP	natural language processing
NN	neural network
OBU	on-board unit
ODD	operational design domain
OEM	(automotive) original equipment manufacturer
PII	personally identifiable information
PMR	public-area mobile robot
QoS	quality of service
ROI	region of interest
SLAM	simultaneous localization and mapping
SOTIF	safety of the intended functionality
SDGs	sustainable development goals
UN	United Nations
V2X	vehicle-to-everything
VR	virtual reality
WHO	World Health Organization

5 Introduction to ITS-specific uses of big data technologies and artificial intelligence techniques

5.1 General

ISO/TS 14812 defines an intelligent transport system (ITS) as a “system comprised of information, communication, sensor and control technologies, that is designed to benefit a surface transport system”. A brief overview of ITS, ITS service domains and main ITS stakeholders is provided in 5.2.

In the context of ITS-specific uses of big data technologies and AI techniques, road safety is paramount. This critical topic is discussed in 5.3.

Big data technologies have become important because organizations have increased the breadth and depth of data collection, and therefore require specialized technologies and techniques to gain insights into, for example, the facts that produced the data. A brief overview of big data technologies and characteristics is provided in 5.4 (see also ISO/IEC 22989).

AI techniques are increasingly applied in various sectors using information technology (IT). A brief overview of AI techniques is provided in 5.5.

Key characteristics of ITS-specific uses of big data technologies and AI techniques are presented in 5.6.

Clause 6 identifies key challenges of ITS-specific uses of big data technologies and AI techniques.

Clause 7 provides short descriptions of a selection of ITS-specific use cases that take advantage of the application of big data technologies and AI techniques.

Annex A contains a structured compilation of the ITS-specific use cases submitted by interested parties using the template presented in Annex B.

The field of artificial intelligence is changing rapidly, as evidenced by the widespread use of generative AI, the proliferation of large language models (LLMs) and deployment of data centres dedicated to AI processing. It is possible that evolution and revolutionary breakthroughs will continue to occur, and apply in varying degrees to ITS use cases; the purpose of this report is simply to identify use cases that can potentially leverage existing or future AI and big data-related technologies.

5.2 Intelligent transport systems (ITS)

5.2.1 General

Intelligent transport systems represent information, communication, and control systems in the field of urban and rural surface transportation, including intermodal and multimodal aspects thereof, traveller information, traffic management, public transport, commercial transport, emergency services, and commercial services. In-vehicle transport information and control systems are excluded.

Benefits of ITS potentially include, but are not limited to, increased safety, sustainability, efficiency, and comfort (see ISO/TS 14812).

5.2.2 ITS service domains

ITS includes eleven broad areas of services. Ten of these are defined in ISO 14813-1 in the context of ITS service domains, which are application areas that include similar or complementary ITS services provided to ITS users:

— Traveller Information

— Traffic Management and Operations

— Vehicle Services

— Freight Transport

— Public Transport

— Emergency Services

— Payment for Transport Related Services

— Weather and Environmental Conditions Monitoring

— Disaster Response Management and Coordination

— Performance Management

The eleventh area of interest is Cooperative-ITS (C-ITS), a subset of ITS where information is shared among ITS stations (as defined in ISO 21217) in a manner that enables its use by multiple ITS services (see the ISO 17465 series for more information on the concepts behind C-ITS).

5.2.3 Main ITS stakeholders

ISO/IEC 22989 defines a stakeholder as any individual, group or organization that can affect, be affected by, or perceive itself to be affected by a decision or activity. A representative taxonomy of ITS stakeholders can be found in the ISO 24315 series on the management of electronic traffic regulations. The ISO 24315 series is considered to be the most relevant document series in this context because it has followed a rigorous systems engineering process, leveraging well established processes in the area of stakeholder engagement (as described in key systems engineering standards, in particular ISO/IEC/IEEE 15288 and ISO/IEC/IEEE 42010). According to ISO/TR 24315-2, ITS stakeholders include:

— Transport users (e.g. vehicle drivers, vulnerable road users)

— Transport infrastructure operators (e.g. traffic engineers, toll road operators, parking facility operators)

— Maintenance and construction personnel (e.g. road crews, maintenance managers)

— Transport service operators (e.g. public transport agencies, delivery companies, ride sourcing

— companies)

— Transport entity owners (e.g. municipalities, campus owners, fleet managers)

— Enforcement personnel (e.g. law enforcement, lawyers, insurance companies)

— Manufacturers and developers (e.g. motor vehicle manufacturers, pathway robot manufacturers, ADS-equipped vehicle developers)

— Technology specialists (e.g. ADS-equipped vehicle experts, location perception experts, video image processing experts)

— Information support entities (e.g. map providers, navigation providers, traveller information providers)

— Advocates (e.g. safety advocates, environmental advocates, disability rights advocates).

5.3 Road safety

5.3.1 General

Intelligent transport system needs are constantly evolving, but road safety remains paramount, as road accidents kill more than 1,3 million people worldwide each year and cause approximately 50 million injuries, according to the World Health Organization (WHO) and the United Nations (UN).

Improving road safety is now recognized as a global challenge. The UN General Assembly therefore unanimously adopted Resolution 74/299[9] to launch the Second Decade of Action for Road Safety 2021–2030 with the explicit target of reducing road deaths and injuries by at least 50 % during this period. This action is in addition to the UN 2030 Agenda for Sustainable Development,[10] which already includes Sustainable Development Goals (SDGs) and targets related to road safety.

To support the implementation of the Second Decade of Action for Road Safety 2021–2030, a Global Plan[8] has been developed by the WHO and the UN Regional Commissions. This Global Plan calls on governments and stakeholders to implement an integrated safe system approach that squarely positions road safety as a key driver of sustainable development.

According to this Global Plan, intelligent transport systems can contribute to the achievement of the UN's objectives. The question of how big data technologies and AI techniques can help intelligent transport systems meet the new challenges remains open. However, a report from OECD/ITF[11] suggests that these technologies hold significant promise.

For example, AI techniques aim to contribute to the proactive management of road networks, with the goal of improving road safety in at least two ways.

— First, through sensors and systems such as computer vision, AI helps to collect and label data on infrastructure condition and traffic events over an entire road network.

— Secondly, thanks to predictive models, an AI system can learn to identify the locations where the risk of an accident is highest before an accident occurs.

5.3.2 The safe system approach to road safety

According to OECD/ITF[12] and PIARC,[13] the safe system approach is a holistic approach to road safety, based on an ethical position that it can never be acceptable for people to be seriously injured or killed on a road network.

The safe system approach acknowledges that humans inevitably make mistakes, and that all parts of the transport system can help prevent a fatal outcome, for example, in the event of a collision.

In a Safe System, those who design, build, manage and use roads and vehicles, and provide post-crash care, all have a shared responsibility. Vehicle design, road geometry and traffic rules reflect the human body's known limits in withstanding crash forces. Roads and streets are "forgiving", for example by protecting road users from impact forces that exceed the limits of human tolerance to injury. Vehicles protect both their occupants and vulnerable road users. Supportive technologies, such as intelligent transport systems, are a key action area.

In addition, an OECD/ITF report[11] proposes a framework for implementing the safe system approach to road safety. This framework is structured around three dimensions:

a) Five key components of a safe system (institutional governance, shared responsibility, holistic approach, preventing exposure to large forces and preventing road-user errors);

b) Six pillars of road safety (road-safety management, safe roads, safe vehicles, safe speeds, safe road-user behaviour and post-crash care); and

c) Three stages of development of any safe system intervention (i.e. emerging, advancing and mature stages).

This framework seeks to correct the impression that road user error is at the heart of the problem. Preventing road-user errors is the finishing touch of the safe system approach rather that its primary focus.

5.3.3 Traditional road safety approaches and the safe system approach

In a safe system, the planning approaches are proactive, identifying risk factors in all parts of the system and seeking to address them before serious harm occurs.[11] The safe system approach puts particular emphasis on building a safe road system, rather than fixing crash accumulation spots.

For instance, rather than trying to eliminate all traffic crashes, the safe system approach focuses on those crashes that result in fatal or serious injuries, and as a goal seeks to eliminate all such injuries, while traditional road safety metrics focus on reductions. Traditional road safety tends toward reactive, incremental approaches, while the safe system approach favours using a systematic approach to proactively target and treat risk, and recognizes that people inevitably make mistakes, but that responsibility ought to be shared by all involved parties (i.e. individuals, system designers), and that elements of any system ought to be combined in such a way as to enhance protections and minimize the impact of a single element failure.

NOTE It is not yet possible to predict when automation will (or will be able to) surpass the ability of a human driver.

5.3.4 Road safety management system

According to PIARC,[13] an effective road safety management system covers three linked elements, periodically reviewed against successful international practice.

a) Institutional management functions: the foundation of an effective road safety management system. Government agencies with primary road safety responsibilities primarily deliver institutional management functions. These functions are also provided through partnerships between the government, civil society and businesses, ensuring alignment with national and organizational goals and targets.

b) Road safety interventions, which focus on the implementation of evidence-based approaches to reduce exposure to risk, prevent serious injury or death, and mitigate injury severity when crashes do occur and reduce consequences of injury.

c) Results (outcomes and outputs), which involves measuring results and setting targets for final outcomes, intermediate outcomes and outputs.

NOTE ISO 39001 is designed to assist organizations in integrating road safety into their management systems as a core objective, as well as aligning with country road safety goals and strategies.[14]

5.4 Big data technologies

5.4.1 General

Based on the definitions provided in ISO/IEC 20546, ISO/IEC TR 20547-1 describes a big data system as a system that:

— processes extensive data sets – primarily in the characteristics of volume, variety, velocity and/or variability – that benefit from a scalable architecture for efficient storage, manipulation and analysis;

— leverages advanced techniques that harness independent resources for building scalable data systems when the characteristics of the datasets call for new architectures for efficient storage, manipulation and analysis;

— employs a paradigm where distribution of data systems across horizontally coupled and independent resources is used to achieve the scalability desirable for the efficient processing of extensive datasets.

According to the OECD Big data report,[16] platforms (e.g. search engines, social networks and marketplaces) are at the heart of the big data ecosystem. They are the main interface between consumers and other market players. These other market players include the following.

— Content providers (e.g. websites, and application developers), who create the information content available on many platforms in exchange for a position in search results.

— Sellers (e.g. manufacturers, consultants), who offer products and services to consumers, and help fund content providers and platforms through the placement of advertising.

— The public sector (e.g. central and local government, public facilities such as hospitals and transport providers), which collects large amounts of data from citizens, and sometimes from platforms and sellers, when the latter provide information to comply with the law.

Operations conducted by big data users are supported by IT infrastructure providers. IT infrastructure providers not only develop the appropriate software to handle big data, but also provide cloud computing and storage facilities, acting as third-party data centres where companies can store and process their data on demand.

According to Reference [15], the volume and variety of data sometimes allows companies to discover correlations from large unstructured databases, and these correlations can outperform results obtained from cleaner but smaller datasets.