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Electronic fee collection — Image-based tolling systems — Measurable characteristics

Perception de télépéage — Systèmes de péage basés sur l'analyse d'images — Caractéristiques mesurables

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Foreword

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This document was prepared by Technical Committee 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 European Commission Implementing Regulation (EU) 2020/204[15] on detailed obligations of European electronic toll service providers includes among the allowed tolling techniques: “electro-optical imaging systems at the toll charger’s fixed or mobile equipment at the roadside, providing means for automatic number plate recognition (ANPR), in EFC systems where the installation and use of an OBE is not required.”

ISO/TR 6026, produced by ISO/TC 204 in collaboration with CEN/TC278, identifies necessary areas of standardization for image-based tolling. Activities to revise existing EFC standards to support ANPR technologies have already been started.

It is well known that certified equipment is required, when ANPR is used for purposes other than tolling (for example, limited traffic zones and speed limit enforcement), and that certification activity requires test suites. This area has so far not been addressed in the field of EFC.

Also, while some phases in the process of electronic fee collection can be devised as technology independent, at least the phases of recognition and the identification of vehicles are strictly dependent on the technology used for tolling, so, in the specific case of ANPR, they depend on the ANPR technology.

Some regional standards (for example, UNI 10772) specify procedures for testing the optical and optical character recognition (OCR) capabilities of ANPR systems, but the process chain of EFC is much wider than that.

A study is needed to identify characteristics of image-based systems for tolling to be tested for conformance to specifications and to measure key performance indicators (KPIs).

It is recognized that image-based systems that are suitable for tolling can be used for other purposes. Although such systems are out of the scope of the present document, informative Annex A is provided with some examples and case studies.

Electronic fee collection — Image-based tolling systems — Measurable characteristics

1 Scope

This document analyses the processes of image-based systems to be used for tolling purposes, with the aim to identify their specific characteristics, and where these characteristics can be observed. The study intends to answer the following questions:

a) Which are the relevant characteristics of an image-based system used for electronic fee collection (EFC)?

b) How can these characteristics be specified?

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/TS 17573-2, *Electronic fee collection — System architecture for vehicle related tolling — Part 2: Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/TS 17573-2 and 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
automated number plate recognition
ANPR
technology to automatically read vehicle registration plates

Note 1 to entry: A vehicle registration plate typically contains the indicator or the code of the country that issued the vehicle registration plate.

Note 2 to entry: Optical character recognition techniques are typically part of the technology associated with automated number plate recognition.

[SOURCE: ISO 17573-2:2020, 3.18]

3.2
enforcement
means to identify and pursue violators of laws, regulations or rules

3.3
false negative
incorrect reporting of a failure when in reality it is a pass

[SOURCE: ISO/IEC TR 29119-11:2020, 3.1.34]

3.4
false positive
incorrect reporting of a pass when in reality it is a failure

[SOURCE: ISO/IEC TR 29119-11:2020, 3.1.35]

3.5
formally valid licence plate
licence plate that has been correctly identified as for the nationality of the vehicle, the characters and the numbers, and the associated format

3.6
free-flow tolling system
collection of tolls on toll roads without the use of physical toll barriers

3.7
constrained tolling system
collection of tolls on toll roads that impose restrictions (in road lanes or speeds, or both) on vehicles where tolls are collected

Note 1 to entry: This covers, among others, all toll booths and toll plazas based tolling systems.

3.8
true negative
correct reporting of a failure when it is a failure

[SOURCE: ISO/IEC TR 29119-11:2020, 3.1.82]

3.9
true positive
correct reporting of a pass when it is a pass

[SOURCE: ISO/IEC TR 29119-11:2020, 3.1.83]

4 Symbols and abbreviated terms

A_r	association rate
A_{tp}	number of correct ANPR results (true positives)
C_r	classification rate
C_m	number of correctly classified vehicles (true or semi-true positives)
D_{fp}	number of detected false positives
D_{fn}	number of detected false negatives
D_{nr},	detection of false negatives rate
D_{pr}	detection of false positives rate
D_r	detection efficiency
$Im_{secondary}$	ratio between the number of vehicles correctly identified by the secondary system and the total number of correctly identified vehicles by the primary and secondary systems
$Ip_{secondary}$	is the number of vehicles correctly identified only by the secondary system
ID_r	identification rate

P_f number of formally identified licence plates

P_r number of identified licence plates corresponding to existing real identified vehicles, that combines the results of both the primary and the secondary systems

V_d is the number of detected vehicles

V_t number of passed vehicles

AI artificial intelligence

ANPR automatic number plate recognition

DSRC dedicated short range communication

EFC electronic fee collection

KPI key performance indicator

LP licence plate

LPN licence plate number

OCR optical character recognition

RSE roadside equipment

5 Framework and classifications of discrete tolling systems

5.1 General — Dimensions of the problem

This document considers the characteristics of tolling systems where tolling is based on a number of geographically fixed identification points where vehicle passages and characteristics of the vehicles are observed. This is in contrast to tolling systems where tolling is based on the continuous recognition of how long (in time or space) a vehicle has travelled in an area or how many times has it crossed borders between defined areas. The considered tolling systems are known as discrete tolling systems.

An initial classification of discrete tolling systems can be made based on the geometrical characteristics of the tolling points, by roughly dividing the systems into free-flow tolling systems and constrained tolling systems. Another dimension, that can have an impact on the system's performance is the presence of multiple tolling technologies (e.g. DSRC manual payments, etc.), and their relevance to the processes incorporated in the tolling system (e.g. process of toll calculation). These and other dimensions add to the physical characteristics (e.g. communication, optical or OCR capabilities) of the tolling devices to form the body of variables to be considered, measured, and ultimately tested, to evaluate the tolling system.

The characteristics of discrete tolling systems that are described in Clause 5 are independent of the technology that is used for tolling.

5.2 General to processes and functional variables

In the US Department of Transportation's classification of congestion pricing technologies,[3] the generic tolling process, independent of the used technologies, can be divided into 7 sub-processes, each one characterized by the set of variables.

The identified sub-processes are as follows (the order is not significant):

— Information and registration — This process is related to all communication aspects of both the tolling system towards its users (signs, barriers, etc.), and the users towards the system (plate registration, installation and personalization of OBE, etc.).

— Passage detection — This process recognizes a vehicle's passage. The process is highly influenced by the geometry of the identification points (free-flow, constrained, etc.).

— Vehicle identification — This process uniquely identifies a vehicle, e.g. by recognizing its licence plate, or by reading its OBE identifier. The process is dependent on the used technology. It can use the same technology as for the passage detection, or a different one.

— Classification — This process classifies an identified vehicle according to the toll regime vehicle classes. This process can be performed with the same technologies used for passage detection or vehicle identification.

— Verifications and reliability — Information collected by the above sub-processes can be verified by further independent processes to enhance its reliability.

EXAMPLE The passage of a vehicle, that is recognized and classified by means of a DSRC transaction, can be verified by reading its licence plate or by the recognition of its axles and dimensions by laser sensors.

— Payment — The payment process is generally independent of the technologies that are used to identify and classify vehicles. However, it can be the case that further evidence is necessary for payment of a toll. For example, it can be necessary that a picture of the licence plate, associated with the time and geographical coordinates of the passage, is associated with a DSRC transaction.

— Enforcement— Enforcement is often associated with a technology alternative to that used for tolling. A typical example is ANPR used to enforce a DSRC-based tolling system.

Not all the above listed sub-processes are necessarily always present in a tolling system. Also, the existence and execution of one sub-process can in some cases influence the behaviour of other sub-processes.

The above sub-processes are listed without any temporal ordering. Figure 1 depicts the sub-processes by outlining, in a grey rectangle, those that characterize a specific EFC system by the tolling technology used.