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PERFORMANCE ASSESSMENT OF BALANCE ALGORITHM BASED MOTORWAY CAR PARK OCCUPANCY INFORMATION SYSTEM

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Abstract: Parking lots are part of the national transport system. Their availability and structure affect the smoothness of vehicle traffic. The use of innovative solutions in this area aims to improve the quality of movement also for lorries. Therefore, the aim of this article was to investigate parking management systems. The study used a method of assessment of entry/exit balancing algorithm based motorway car park occupancy information systems has been proposed. Adequate criteria and quality measures have been indicated; procedures of setting the measures in the process of the system's certification and their applicability to selected NeuroCar Park Balance installations have been described. External factors influencing the efficiency of the systems and recommendations concerning verification procedures in commercial conditions have also been referred to. The benefits and difficulties of applying a management system for parking lots for trucks on the route were identified based on the measurements made.

Key words: car park, occupancy, information, system, NeuroCar Park Balance

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Introduction

The main function of parking information systems is to provide reliable information on currently available parking places. As experienced by German parking systems operators, reliability is a key factor taken into account by drivers, convincing them to adhere to the recommendations issued by the Parking Information System (PIS) (Malasek, 2019; Szulc, 2019). The systems are based on the exact detection and classification of vehicles on entry and exit (Borisova, 2019). From the point of view of a motorway user, it is not important which parking place at the chosen car park is unoccupied (Parmar et al., 2020). What is important is reliable information if it would be possible to park the car once one has entered the car park (Maśniak et al., 2019; Shang et al., 2019; Obrecht et al., 2018; Dhonde and Patel, 2021). To that end, entry/exit vehicle balancing systems prevail at motorway lorry car parks (Gies, Hertel, Tully, 2021).
Unreliable information about potentially available parking places makes drivers distrustful of such systems and unwilling to make use of their recommendations (Kalasova et al., 2021; Qian and Rajagopal, 2014). This, in turn, leads to the unbalanced placement of vehicles not only among car parks but also within one car park, e.g. when

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vehicles are parked on an emergency lane in front of and on entry, even though there are unoccupied parking places further inside the car park in its lorry sector (Weenen et al., 2019; Kovács, 2017; Frankovský et al., 2020).

The ongoing status of the car park is calculated as a sum of the entering (increase) and exiting (decrease) vehicles. The values are calculated separately for passenger cars and lorries, with consideration for the length of the vehicle and the parking place it occupies. Each detected entry/exit results in an update of the car park status. The balancing systems' operation is based on the accurate detection of vehicles on entry and exit (Qian and Rajagopal, 2014; Tu, 2019; Straka, 2021; Urbański et al., 2021). They consist of the following components:

-system of identification (detection, classification, number plate recognition) of the vehicle on entry and exit from the car park with accuracy approximating 100%;

-balancing system based on vehicle identification on entry and its confirmation on exit by verifying its number plate or characteristics of its silhouette;

-surveillance system (usually video cameras streaming lower resolution images), also used as a reference system supporting the car park operator in making decisions regarding the manual correction of car park status.

The car park occupancy is described as the number of available parking places for the vehicles of a given class (Ji et al., 2017). Usually, the only data made accessible by car park information systems refers to lorries. The number of available parking places is calculated as a difference between the nominal or maximum allowed number of parking places and the number of vehicles currently on the premises, as defined by the balancing system (Molan, Simićević, 2018; Azshwanth et al., 2019; Straka et al., 2019; Straka et al., 2021). To determine numbers of unoccupied parking places in a way resembling that of individual drivers is a complex task, which involves a comparison of two independently set values (Sewagudde, 2016):

-number of parking places potentially available for lorries,

-number of lorries indicated by the system as present at the car park.

Every car park contains a determined number of ground surface marked parking places for lorries – that is a nominal number. As the car park becomes fully occupied, certain vehicles may tend to park also off the designated areas, e.g. along driving lanes or a lane for oversized vehicles (Rye et al., 2015; Ingaldi, 2018). Since the nominal number is usually exceeded, most operators use the notion of the so-called maximum permitted car park occupancy. This amounts to a maximum number of lorries that are allowed to occupy the car park simultaneously.

Regulations regarding verification of parking space balancing systems

In response to a stable increase in demand for parking places along the transit routes in Europe, appropriate regulations have been introduced in many European countries, e.g. in Germany. The basis for those has been the “Guidelines for verification of motorway car park occupancy assessment systems” commissioned by BASt (Modelling Parking…, 2014; Idris et al., 2009) and prepared in 2013.

In reference to those guidelines and own experiences, the entities responsible for the development and maintenance of the car park infrastructure have laid down their procedures for qualification and validation tests (Szmidt, 2017):
-assessment procedure of car park balance system operation commissioned by Southern Bavaria Traffic Management System (ABDSB - Autobahndirektion Südbayern); certification tests based on the aforementioned procedure were introduced in co-operation with and under supervision of Fraunhofer Institute of Road Traffic and Infrastructure Engineering in Dresden;
-assessment procedure of the quality of LBM (Landesbetrieb Mobilität Rheinland-Pfalz - State Office for Mobility Rhineland-Palatinate) car park occupancy system operation, set up within tender specifications, vital for the tender for installation and launch of car park systems by the BAB A61 motorway; verified upon the customer's request by VIA Berlin company;
-guidelines regarding the assessment criteria of car park balance systems and boundary conditions for their verification developed by R&BRI (Road and Bridge Research Institute) in support of the NeuroPark research project between 2016 and 2017; verification is run by R&BRI on their own testing grounds.
The most complex procedure is applied in pre-qualifying ABDSB tests; therefore, its principles have been described in detail below.

Methodology

In purpose of evaluating the capacity of a car park, further applied the procedure in pre-qualifying ABDSB tests (Sewagudde, 2016; Švedova et al., 2017) based on four quality criteria that must be met in defined boundary conditions:
Criterion 1: precision of detection and classification,
Criterion 2: uniformity of classification,
Criterion 3: system's performance stability,
Criterion 4: operating correctness in untypical conditions.
The random sample consists of at least 200 consecutive vehicles (regardless of their class) that have passed through the measurement point. Percentage of heavy goods vehicles (L1, L5, L6) must not be lower than 10 %. The total participation of P2, P3, L2, L3 and L4 vehicles must not be lower than 5 % (within the 200 vehicle passes). That ensures sufficient precision of classification. If necessary, the random sample should be extended until the aforementioned minimum values have been reached. Each passage should be recorded by the tested system in an unambiguous manner, with at least the vehicle's ID, class and timing.
The verification is based on figures generated by the reference system. The latter should make it possible to create a list of vehicles passing through the measurement point with records of precise timing and vehicle classes. Both factors interlinked show if the vehicle has been recorded by the system and to which class it has been assigned.
The random sample numbers are given of wrongly classified, miscounted and unverified vehicles on entry and exit. Errors are verified independently for each place

of record, i.e. if a vehicle has been wrongly classified as a passenger car on both entry and exit, two cases of the wrong classification are recorded. Errors in total regarding both entry and exit account for the imprecision of classification.

Criterion 1: Precision of detection and classification

Accuracy of detection and classification of vehicles on measurement points on entry and exit should be verified in a period of intensified lorry traffic. Vehicles passing the measurement point are recognised (detection, number plate recognition) and attributed to either vehicle group (classes). In reference to Criterion 1, the system has to fulfill the following requirements:

-at least 80 % of passenger cars with trailers and light commercial vehicles have to be classified correctly. For all remaining types of vehicles, the correct classification has to amount to at least 99 %;

-the requirements shall be met separately for random samples of at least 200 vehicles on entry and at least 200 vehicles on exit.

Criterion 2: Uniformity of classification on car park point of entry and point of exit

That should be verified alongside tests according to Criterion 1. Consecutive 200 vehicles entering the car park and registered on both measurement points undergo such verification.

Participation of heavy goods vehicles (L1, L5, L6) in the study group has to equal or exceed 10 %. For vehicles P2, P3, L2, L3 and L4, their joint participation must not fall below 5 % (in reference to 200 passages). If the aforementioned minima have not been reached, the random sample should be expanded as much as necessary to attain the required values.

To determine the level of uniformity of classification, the number of vehicles that have been assigned the same class on both entry and exit is specified during each such procedure. Their share in the random sample should amount to or exceed 99

Criterion 3: Stability and precision of car park occupancy calculation

The verified parameter is a difference between the status of the car park assessed by the tested system and its actual status as reflected by the reference system. Thus defined occupancy inaccuracy cannot exceed required boundary values over the whole testing period. No less than 12 hours should pass between the latest adjustment of car park status and the start of the test.

Standard verification lasts 10 days; on each day, at least 10 scheduled samples are verified. For each sample, a comparison is made between the real number of vehicles staying at the car park (data from reference system) with the number of vehicles of a particular class recorded by the system. An important factor in the comparison is time compliance between the tested and reference systems. Moreover, delays should be taken into account resulting from the processing time of data generated by the system, i.e. the time that passes between vehicle's entry in the detection area and the moment the event is fully processed by the balancing system. The delays should not exceed 10 seconds. In reference to Criterion 3, the system must meet the following requirements:

-For 90 % of random samples, car park occupancy inaccuracy cannot exceed the value of +/- 2 passenger cars and +/- 3 heavy goods vehicles.
-Car park occupancy inaccuracy for all random samples within the testing period cannot exceed the value of +/- 4 passenger cars and +/- 5 heavy goods vehicles.
Defining the car park status based on a reference system (counting vehicles on the spot or on the basis of surveillance camera records) must be properly documented.

Criterion 4: System's operating correctness in untypical conditions

The system should correctly recognise the class and direction of movement (influencing the car park status) of the vehicle in defined untypical situations taking place on measurement points. Verification shall be performed on measurement point on entry or exit, simulating defined situations with heavy goods vehicles and passenger cars. The lane width on the measurement point should permit parallel passages of two heavy goods vehicles, yet it should also prevent them from passing with a gap of more than 50 centimetres. Untypical situations refer to the following cases:
-vehicle of any class changes direction in measurement field – leaves the field → the system should correctly identify the vehicle class and its influence on car park status (entry, exit),
-while a vehicle of any class (heavy goods vehicle or passenger car) slows down or stops in measurement field, another vehicle of any class moving in any direction passes the other one by → the system should correctly identify the vehicle class and the influence on car park status (entry, exit) of both vehicles,
-vehicles of any class move in the same direction one by one with a gap below 1.5 metres → the system should record the passage of two vehicles and correctly recognise their classes.
Simulation of each of the aforementioned situations should be repeated 8 times. For 120 test situations, up to 5 inaccurate interpretations done by the system are allowed.

Test conditions for the four criteria

For criteria 1 and 2, verification should be conducted on weekdays in the period of intensive heavy goods vehicles traffic at car parks. It should not be conducted at weekends or on days immediately preceding or following these. There should be at least a 12-hour gap, or at least 1.000 vehicles should pass through the measurement point between the latest manual adjustment of the car park to the commencement of tests.
It is recommended that verification occurs in the afternoon when drivers take a compulsory break. Verification on entry and exit shall be completed with data of vehicles exiting the car park on the morning of the following day.
Examples of recommended periods:
-Tuesday afternoon/evening (15:00-20:00) on entry and exit as well as Wednesday morning (05:00-10:00) on exit or
-Wednesday afternoon/evening (15:00-20:00) on entry and exit as well as Thursday morning (05:00-10:00) on exit.
Verification criterion 3 should last for at least 10 consecutive days. It is recommended that these include no more than one weekend and no holidays or school breaks.

At least 10 samples are collected every day, from early morning (when heavy goods vehicles begin to leave after the night rest) to late evening (when vehicles return for the night rest). The following hours (local time) are recommended for sampling:
-in the morning at 6:00, 7:00, 8:00 and 9:00,
-in the afternoon at 13:00,
-in the evening at 17:00, 18:00, 19:00, 20:00 and 21:00.
There is no set time frame for verifying criterion 4 for untypical cases. According to the remaining criteria, tests may be conducted independently from system verification.

Boundary conditions of tests and testing ground

Certification of balancing systems should be conducted on custom-built testing grounds – adapted large car parks located beside motorways, fulfilling the following requirements:
-car park with petrol station or at least provided with toilet (WC),
-average traffic volume at the car park (total number of entering and exiting vehicles) at least 1.000 / 24 hrs,
-average traffic volume on the adjacent road – at least 10.000 / 24 hrs,
-one-lane entry and one-lane exit, permitting parallel low-speed passages of two lorries.
Precision of detection and classification must be guaranteed in all weather and lighting conditions. The following conditions should occur during the test:
-low angle of sunrays against arriving vehicles (number plate overexposure),
-heavy rainfall (≥ 15mm/h),
-heavy snowfall (visibility below 50 metres),
-fog with visibility below 50 metres,
-lack of daylight and artificial lighting (at night).
Verification of system operation at night is indispensable. Required functionality in other weather and lighting conditions must be confirmed in writing by the entity submitting the system for tests.
The certification procedure included the assessment of criteria 1-3 for the car park occupancy test (1-3) using the ABDSB system in the PWC Gelbelsee West car park and the analysis of non-standard cases (criterion 4) using the LBM system in the car park PWC Engelrödchen and T&R Wonnegau Ost.

Testing of the NeuroCar Park Balance system accord with the ABDSB

The main NeuroCar Park Balance certification tests were performed in accord with the ABDSB methodology at PWC (MOP with toilet (WC) Gelbelsee West car park in Bavaria (Germany). It is the ABDSB testing ground equipped with appropriate measurement infrastructure and a reference system based on surveillance cameras. The car park's infrastructure is prepared to be connected with (tested) external measurement systems.
The PWC Gelbelsee West car park is located by the A9 motorway, ca 70 kilometres from Nuremberg towards Munich. It contains 35 lorry parking places. Average daily traffic volume in the monitored direction on the motorway beside the car park amounts to ca 37.500 vehicles (Fixed Traffic Measurement Point Greding), including ca 6.000

lorries. The car park is occupied by ca 900 vehicles daily and is connected to the BayernInfo Parking Information System.
Layout of the systems and parameters of the testing ground has corresponded with the measurement points at the PWC Gelbelsee West car park. The system submitted for certification is owned by Neurosoft company. It consisted of two measurement units installed on entry and exit as well as of calculating units (Figure 1).

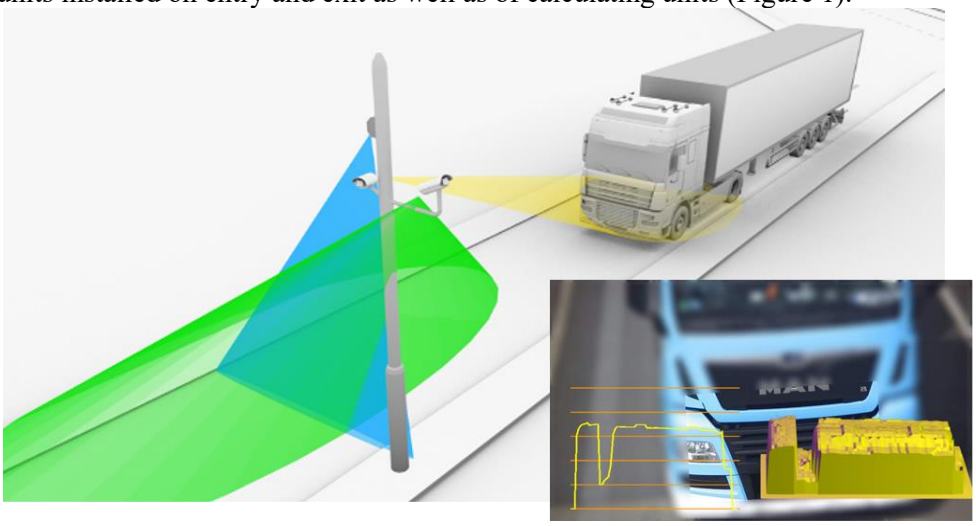

Figure 1: Scheme of a measurement point

The key element of the NeuroCar Park Balance system is the balancing module (balancer). Balancing consists of regular counting and recording events (entries and exits) from the moment when the system is restarted. The latter happens every several days so that long term correlations are effectively used without overburdening the system with compared events in great numbers.
During the calculation of events, the entering vehicles are added to the list of vehicles present within the parking space, whereas the exiting vehicles are removed from that list. The entry-exit pairing is done on the basis of counted measures of similarity between the events, whose setting is based on specially developed heuristic rules.
Additionally, certain mechanics have been implemented in the balancing module to correct errors in determining the car park status, which is automatically activated. The basis for that is the parking schedule defined for the car park, including deadlines for leaving the area.
Verification of all criterium was successfully completed, and the result was positive. Checking of criterion 1 was based on a random sample recorded on 14th March 2017 between 15:00 and 20:00 (entry and exit) as well as on 15th March 2017 between 05:00 and 09:00 (exit). Heavy goods vehicles' share was 32.5 % on entry and 45 % on exit (requirement: above 10 %), the share of passenger cars and light commercial vehicles with trailers – 11 %on entry and 6.5 % on exit (requirement: above 5 %).

Verification criterion 2 was based on a random sample of 200 consecutive vehicles, recorded on 14th March 2017 after 18:30 (with lack of daylight) on entry and exit. Heavy goods vehicles' share was 32.5 % (requirement: above 10 %), share of passenger cars and light commercial vehicles with trailers – 11 % (requirement: above 5 %). Only one passenger car (P1) in the whole sample was not uniformly classified on both measurement points (99.5 %).

Checking of criterion 3 was on 10 consecutive days between 11th and 20th March 2017. It was assumed that on each day, 10 samples would be collected according to certification procedure, at least 4 of which at night. Due to temporary haze, which made manual verification impossible, the collection of some of the samples was delayed until the possibility of visual verification returned.

For each sample, sufficient numbers of vehicles of both basic classes were recorded, as set by the system and fixed in the course of visual verification. The following results were obtained for heavy goods vehicles:

-absolute deviations over 5 vehicles – for 0 % samples (requirement: 0%),

-absolute deviations over 3 vehicles – for 7 % samples (requirement: below 10 %).

Deviations in the class of passenger cars have not exceeded permitted values either.

Operating correctness in untypical conditions in criterion 4 was verified on testing ground in Wrocław in the afternoon of 15th Aug. 2017, under the supervision of the representatives of IVI Fraunhofer Institut, ABDSB and IBDiM. Simulation of all 15 untypical situations was conducted with at least 8 repetitions of each of them. The results were presented online in front of the supervisory committee and recorded in the calculating unit. Only in two test cases regarding a parallel passage of passenger cars in one direction (situation 11) and in two different directions (situation 15), the system has misinterpreted the measurement data, respectively, once and twice. In all remaining untypical situations, the system worked properly. The final result (3/120) was within permissible error limits (up to 5 misinterpretations per 120 passages).

Testing procedure adaptation according to LBM

The PWC Engelrödchen car park is located by the A61 motorway in Rhineland-Palatinate. It contains 35 lorry parking places. Average daily traffic volume in the monitored direction on the motorway beside the car park amounts to ca 25.300 vehicles (Fixed Traffic Measurement Point Boppard), including ca 5.850 lorries (= ca 22 %). The car park is occupied by ca 600 vehicles daily, where lorries account for ca 35% and is connected to the LBM Parking Information System.

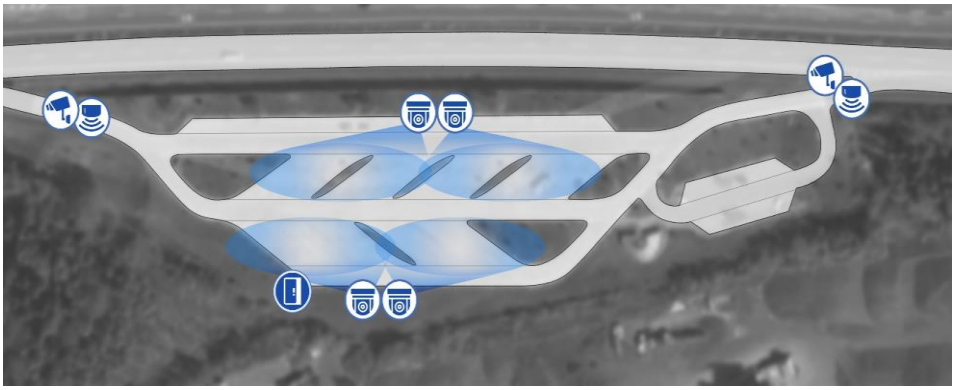

Figure 2: PWC Engelrödchen car park layout marked with icons of parts of parking and surveillance systems

The basic NeuroCar Park Balance system has been installed at the car park, which consists of the following elements (Figure 2):
-measurement point on entry, equipped with ANPR camera and two scanners, boom-mounted in the middle of the traffic lane and connected with the calculating unit;
-measurement point on exit, equipped with ANPR camera and two scanners, boom-mounted in the middle of the traffic lane and connected with the calculating unit;
-the calculating unit installed in the central data transmission distribution frame is equipped with a module for communication with the central system.
The T&R Wonnegau Ost car park (figure 3) is located by the A61 motorway in Rhineland-Palatinate. It contains a petrol station (T=Tankstelle) and a restaurant (R=Raststätte). There are 52 lorry parking places there and a parking lane for oversized vehicles. Average daily traffic volume in the monitored direction on the motorway beside the car park amounts to ca 26.700 vehicles (Fixed Traffic Measurement Point Worms), including ca 6.000 lorries (= ca 22 %). The car park is occupied by ca 1.300 vehicles daily, where lorries account for ca 25 % and is connected to the LBM Parking Information System. Apart from entry and exit to the motorway, the car park also has a service lane connected with the local road. The lane is used by road services or security forces but is also available for local traffic. For this reason, the expanded NeuroCar Park Balance system was installed at the car park, which consists of the following elements like measurement point on entry, measurement point on exit, measurement point on service lane and the calculating unit.

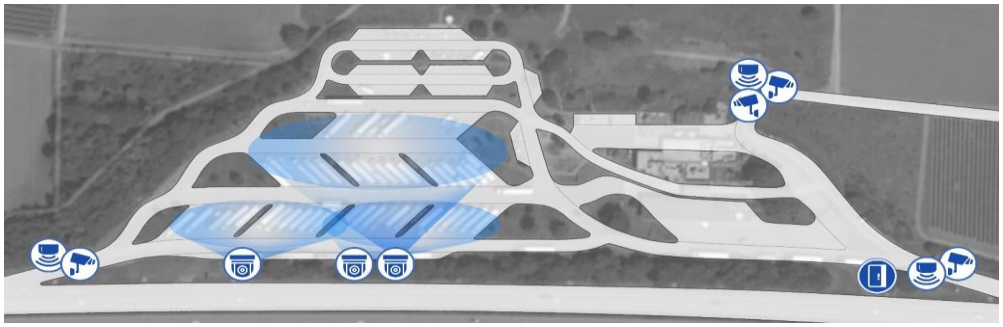

Figure 3: T&R Wonnegau Ost car park layout marked with icons of parts of parking and surveillance systems

The system verification principles are contained in LBM tender specification. They are based on ABDSB certification procedure, adjusted in the manner described below to accept systems installed on LBM order. Two test variants have been applied to differ in numbers of daily samples – the extended variant at PWC Engelrödchen and the basic variant at T&R Wonnegau Ost. The functionality of parking space balancing system was tested with the following assumptions made:

-The procedure was limited to meeting requirements related to stability and reliability of system operation (Criterion 3), whereas testing precision of detection and uniformity of classification was not required, neither was a verification of system operation in untypical conditions.

-Verification lasted for 10 consecutive days.

-At PWC Engelrödchen, samples were collected 10 times a day (extended procedure) at 05:00/06:00/07:00/, 11:00/13:00 and 16:00/17:00/18:00/19:00/20:00; 5 samples were collected at night.

-At T&R Wonnegau Ost, samples were collected 2 times a day (basic procedure):

-in the morning when most heavy goods vehicles had left, and not many vehicles were present at the car park (usually between 08:00 and 11:00);

-in the afternoon before the car park was full of vehicles, but occupancy approximated capacity (usually between 16:00 and 18:00);

-samples were collected at night only when the car park's occupancy was approximating maximum after sunset and when the weather conditions permitted undisturbed counting of vehicles based on camera records.

-Solely heavy goods vehicles were verified, with passenger cars and light commercial vehicles with trailer as well as buses; the number of vehicles recorded by surveillance cameras was compared with the car park status determined by the system.

-All cases of hesitant classification when choosing between light commercial vehicles and lorries were solved in favour of the system indications.

-If at a set time (sample) the number of lorries present at the car park exceeded the nominal number of parking places and it was impossible to determine the actual number of the former, the contracting entity has agreed on using the term “car park overfilled”; in such cases, it was assumed that the system operated correctly.

-The maximum permissible measurement error for lorries was established as 2 vehicles + 3 % of parking places, which corresponded to, respectively:

-for PWC Engelrödchen with 35 parking places – 3 lorries,

-for T&R Wonnegau Ost with 52 parking places – 4 lorries.

-Only one requirement had to be met – the maximum permissible error could not be exceeded for 90 % random samples; there was no requirement regarding a maximum permissible error for the number of parking vehicles.

Both the tested and reference systems used the same time server, which enabled full synchronisation of the test material. Furthermore, compensation of errors resulting from system delays was possible: to the indicated car park status with a particular time signature were added or deducted from it the vehicles that either entered or exited the car park between defining the status and generating the images used as reference material.

Test results for parking cars

PWC Engelrödchen car park

The stability of operation of the PWC Engelrödchen car park's balancing system was verified between 27th Feb. and 8th March 2019. The tests were done over 10 consecutive days, including one weekend (2nd/3rd March). According to a fixed schedule, 10 samples were collected every day. For each sample, the number of lorries determined by the system (the cark park status + changes resulting from the traffic) was matched with the number of vehicles identified through visual verification. The conditions at the car park permitted visual verification during the whole test.

The permissible error in calculating the parked vehicles (3) was exceeded for 9 of 100 samples. All of them were collected successively between Sunday afternoon (3rd March, 13:00) and Monday morning (4th March, 07:00). The error was subsequently compensated for by the balancing module, and it was likely caused by the system autocorrect, which prematurely removed vehicles parking during the weekend (longer than 72 hours) from the car park status.

The distribution of measurement errors is displayed in Figure 4: negative values denote insufficient indication of vehicles by the system in comparison with the actual number; positive values refer to indications exceeding the actual number.

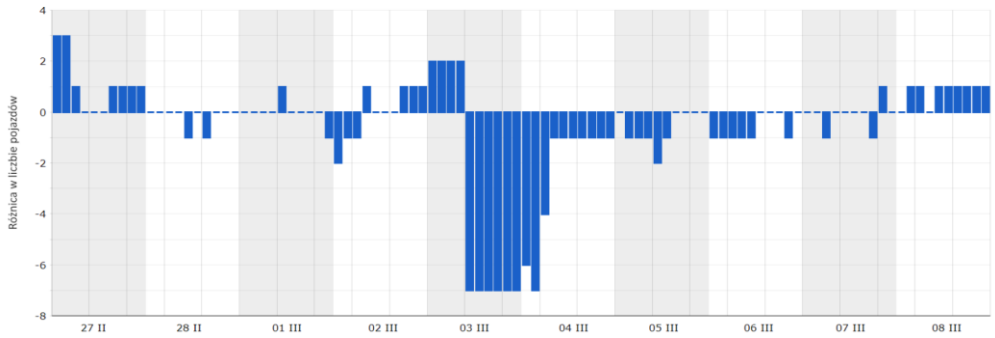

Figure 4: PWC Engelrödchen– results of analysis of samples taken during qualifying tests

Test result: Requirements concerning system's performance stability (90 % of samples cannot exceed the permitted inconsistency in car park status) were met. Since the test, the balancing system's performance has been very stable, even in unfavourable weather conditions.

T&R Wonnegau Ost

Stability of operation of the T&R Wonnegau Ost car park's balancing system was verified between 10th and 19th Sept. 2019. The tests were done over 10 consecutive days, including one weekend (14th/15th Sept.). Two samples were collected every day: one in the morning – when only a few lorries were present at the car park, and the other in the afternoon when the car park was full. For each sample, the number of lorries determined by the system (the cark park status + changes resulting from the traffic) was matched with the number of vehicles identified through visual verification. The vehicles were also calculated in cases where the number of those present at the car park exceeded the number of parking places (at weekends). The conditions at the car park permitted visual verification during the whole test.

The maximum permissible error in determining the number of parked vehicles (4) was not exceeded for any of the 20 collected samples.

The distribution of errors is shown in Figure 5: negative values correspond with too few vehicles when compared to those actually present at the car park; positive values stand for the reverse situation.

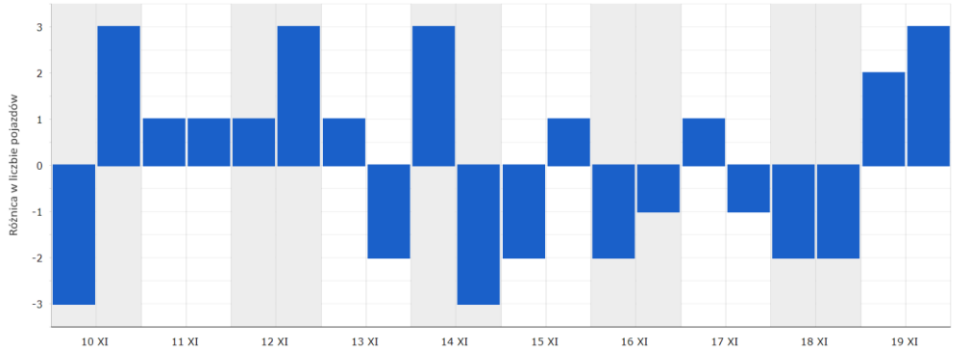

Figure 5: T&R Wonnegau Ost – results of analysis of samples taken during qualification tests

Test result: Requirements concerning system's performance stability (90 % of samples cannot exceed the maximum permissible error in the car park status) have been met.

Generally speaking, since the test took place, the balancing system's operation has been uninterrupted, also in unfavourable weather conditions. However, at random intervals, new untypical events have occurred at the car park that the system has not been trained to recognise, and therefore, it has not learnt to interpret them correctly. During the acceptance procedure, the following situations have been observed:

-leaving trailers and semi-trailers at the car park for periods longer than 3 days – the parked trailers temporarily occupied even more than 20 % of the area; the error results from the algorithm correcting the car park status, which removes from it after 72 hours the vehicles unrecognised on exit;
-parking on both sides of entry immediately outside the measurement field causing untypical manoeuvres in the measurement field;
-detection errors connected with the movement of groups of people or people with animals in the measurement field (walking with dogs through service entry).
In the aforementioned situations, the evaluation implemented by the system may prove inaccurate, which, in turn, may lead to temporarily inappropriate car park status indications.

Results and Conclusions

The remarks and recommendations presented below result from experiences gathered in the course of certification procedure and acceptance procedure at PWC Engelrödchen and T&R Wonnegau Ost car parks. Simplification of the procedure of qualification tests seems sensible and sufficient to check the system's main functions. Test considering only heavy goods vehicles, including buses as well as passenger cars with trailers and light commercial vehicles with trailers – all of them occupying parking places crucial for the parking information systems. Test done over 10 consecutive days, with two samples collected every day – the first one in lowest occupancy (when it is easy to verify the car park status), and the second one in the afternoon, in ca 80 % occupancy (when heavy goods vehicles most intensively search for parking places). Test limited to Criterion 3 according to ABDSB methodology – to verification of reliability and stability of the system in determining the number of vehicles present at the car park. Verification consists of comparing the car park status determined by the system with the actual number of vehicles present there, which is the most important information about the parking information systems. Nevertheless, it is necessary to point out that high effectiveness and accuracy in determining the occupancy is impossible without very precise detection and identification (classification) of vehicles on measurement points.
Detection errors may temporarily make balance systems dysfunctional; then the car park status correction is necessary, either automatic or manual. The main factor disrupting the performance of the identification module is untypical (not addressed in certification procedure) manoeuvres in the measurement field (reversing, repeated stopping, turning, driving diagonally, wrong-way driving), and also prolonged parking. An oversized or untypically shaped vehicle may cause the wrong classification as well. Depending on configuration and dynamics of its passage through the measurement point, it may be identified as either one vehicle or a few vehicles representing different classes. Another potentially disruptive factor is extreme weather conditions (fog, heavy rainfall or snowfall), which may limit the efficiency of sensors (camera, laser), directly or indirectly, by covering number plates and therefore spoiling detection. Incorrect assessment of car park occupancy may also be caused by misinterpreting either two vehicles as one or one-piece vehicles consisting of two parts. In order to limit remote supervision and periodic

adjustments of the car park status, balancing systems should contain integrated error compensation modules, active towards at least the errors of detection and classification. If such a functionality is not provided, every detection error leads to dysfunction until manual recalibration. Balancing systems in operation should be subject to regular supervision based on dedicated tools. Apart from obtaining automatic notifications of technical defects, the operator should have easy access to monitoring and verifying the car park status. Furthermore, it is advisable to introduce systems detecting and reporting untypical situations on the basis of statistical analysis of current (detection and balance) measurement data.

Summary

Technology has to be tested, and it is even more evident where the technological devices shall be accessed directly by people; therefore, they are supposed to be user-friendly. One of the main advantages required of parking information systems is that they need to provide reliable information about the currently available parking places. NeuroCar Park Balance system has been tested in Germany, with the crucial role of reliability and functionality taken into account. The following values were compared: number of parking places potentially available for lorries and number of lorries indicated by the system as present at the car park. Considering the current volumes of land transportation in Europe as well as its growth potential, motorway car park occupancy information systems will certainly be further modernised and tested.

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OCENA WYDAJNOŚCI SYSTEMU INFORMACJI O DOSTĘPNOŚCI MIEJSC PARKINGOWYCH W OPARCIU O ALGORYTM BILANSOWY

Streszczenie: Parkingi są częścią krajowego systemu transportowego. Ich dostępność i struktura wpływają na płynność ruchu pojazdów. Zastosowanie innowacyjnych rozwiązań w tym zakresie ma na celu poprawę jakości ruchu także pojazdów ciężarowych na trasie. Dlatego celem tego artykułu było zbadanie systemów zarządzania parkingami. W pracy zastosowano metodę oceny algorytmów równoważenia wjazdów/wyjazdów w oparciu o systemy informacji o zajętości parkingów autostradowych. Wskazano adekwatne kryteria i mierniki jakości, opisano również procedury ustalania mierników w procesie certyfikacji systemu oraz ich zastosowanie do wybranych aplikacji tj.: NeuroCar Park Balance. Odniesiono się również do czynników zewnętrznych wpływających na sprawność systemów oraz zaleceń dotyczących procedur weryfikacji. Na podstawie przeprowadzonych pomiarów zidentyfikowano korzyści i trudności w stosowaniu systemu zarządzania parkingami dla samochodów ciężarowych będących w trasie.

Słowa kluczowe: parking, obłożenie, informacja, system, NeuroCar Park Balance

基于平衡算法的高速公路停车场占用信息系统性能评估

摘要：停车场是国家交通系统的一部分。它们的可用性和结构会影响车辆通行的顺畅性。在该领域使用创新解决方案旨在提高卡车的运动质量。因此，本文的目的是研究停车管理系统。该研究采用了一种基于高速公路停车场占用信息系统的入口/出口平衡算法的评估方法。已经指出了足够的标准和质量措施，还描述了在系统认证过程中设置措施的程序及其对选定的 NEUROCAR PARK BALANCE 装置的适用性。还提到了影响系统效率的外部因素以及有关商业条件下验证程序的建议。根据所做的测量，确定了在路线上应用卡车停车场管理系统的好处和困难

关键词: 停车场, 占用, 信息, 系统,