

RISK IDENTIFICATION AND ADVICE GENERATION FOR VEHICLE DRIVERS

TECHNICAL FIELD

[0001] Various aspects of the present disclosure are related to a computer system for generating driving-related instructions to reduce a driving-related risk, and to methods thereof (e.g., a method of generating driving-related instructions to reduce a driving-related risk).

BACKGROUND

[0002] In general, commercial vehicles for the transport of goods or passengers constitute a fairly large portion of the traffic present on the streets. Commercial vehicles include, for example, coaches for transporting passengers, trucks for transporting products or livestock, and the like. In this context, it is of utmost importance to ensure that a commercial vehicle is operated safely, with the aim of reducing or preventing damages and injuries to the driver, the passengers, the transported livestock or goods, other traffic participants, etc. Various factors contribute to a safe operation of a commercial vehicle, for example a regular maintenance of the vehicle, a replacement of old or defective components, regular training of the drivers, and the like. In particular, risks related to drivers may constitute an area of particular relevance, because different drivers tend to have different habits, e.g. in relation to the driving style, lifestyle, etc., so that it may prove difficult to ensure a uniform driver behavior even for the same type of commercial vehicles, or within the same fleet of commercial vehicles.

[0003] Therefore, advanced strategies for evaluating and assisting drivers of commercial vehicles may enable a more accurate identification of specific weaknesses and prompt the implementation of corrective actions to reduce the overall risks related to the operation of a commercial vehicle.

SUMMARY

[0004] According to various aspects, a computer system for generating driving-related instructions may be provided, the computer system including: a processor; and a memory configured to store instructions, wherein the instructions, when executed by the processor, cause the processor to: obtain driving contextual data associated with a driver, wherein the driving contextual data are representative of driver-related parameters influencing a driving performance of the driver; determine a personalized risk profile associated with the driver based on the driving contextual data, wherein the personalized risk profile includes a risk score associated with a driving-related risk for the driver and risk factors influencing the risk score;

determine a risk scenario associated with the driver based on the personalized risk profile, wherein the risk scenario is representative of driving-related conditions causing an increased driving-related risk for the driver; and determine the driving-related instructions associated with the driver based on the personalized risk profile and on the risk scenario. The features mentioned in this paragraph provide a first example.

[0005] According to various aspects, the driving-related risk may include one or more events, and the instructions may be further configured to cause the processor to determine the personalized risk profile associated with the driver by evaluating the driver-related parameters with respect to a corresponding criterion for each of the one or more events. The features mentioned in this paragraph in combination with the first example provide a second example.

[0006] According to various aspects, the instructions may be further configured to cause the processor to determine the personalized risk profile associated with the driver by comparing the driver-related parameters with a corresponding threshold for the one or more events or with a corresponding binary condition for the one or more events. The features mentioned in this paragraph in combination with the second example provide a third example.

[0007] According to various aspects, the instructions may be further configured to cause the processor to cause a transmission of the generated driving-related instructions to a user device communicatively coupled with the computer system. The features mentioned in this paragraph in combination with any one of examples one to three provide a fourth example.

[0008] According to various aspects, the driving-related instructions may include vehicle instructions addressed to a vehicle driven by the driver and configured to prompt the vehicle to implement an autonomous functionality to reduce the driving-related risk associated with the driver. The features mentioned in this paragraph in combination with any one of examples one to four provide a fifth example.

[0009] According to various aspects, the driver may be a driver of a commercial vehicle part of a fleet of commercial vehicles; and the driving-related instructions may include operator instructions addressed to an operator of the commercial fleet. The features mentioned in this paragraph in combination with any one of examples one to five provide a sixth example.

[0010] According to various aspects, the operator instructions may be representative of a rostering for the commercial fleet including the driver. The features mentioned in this paragraph in combination with the sixth example provide a seventh example.

[0011] According to various aspects, the driving-related instructions (e.g., as part of operator instructions) may include or may be representative of one or more simulation parameters to

define a simulation environment for training the driver. For example, the one or more simulation parameters may set the simulation environment, or may provide adjustments to a user-defined simulation environment previously set via user-defined parameters. The features mentioned in this paragraph in combination with any one of examples one to seven provide an eighth example.

[0012] According to various aspects, the instructions may be further configured to cause the processor to determine the one or more simulation parameters based on the risk scenario for the driver, wherein the one or more simulation parameters define a simulation environment that reproduces the risk scenario identified for the driver. Illustratively, the simulation environment defined/adjusted by the one or more simulation parameters enables a training of the driver targeted to the identified risk scenario. The features mentioned in this paragraph in combination with the eighth example provide a ninth example.

[0013] According to various aspects, the driving contextual data may include physiological data of the driver. The features mentioned in this paragraph in combination with any one of examples one to nine provide a tenth example.

[0014] According to various aspects, the instructions may be further configured to cause the processor to: select one or more events; and assign a respective weight to each of the selected events, and define the driving-related risk for the driver as a weighted combination of the selected events. The features mentioned in this paragraph in combination with any one of examples one to ten provide an eleventh example.

[0015] According to various aspects, the instructions may be further configured to cause the processor to: assign the driver to a corresponding driver group based on one or more driver characteristics represented by the driving contextual data associated with the driver. The features mentioned in this paragraph in combination with any one of examples one to eleven provide a twelfth example.

[0016] According to various aspects, the instructions may be further configured to cause the processor to determine the personalized risk profile for the driver according to the driver group to which the driver is assigned. The features mentioned in this paragraph in combination with the twelfth example provide a thirteenth example.

[0017] According to various aspects, the driving-related risk may include one or more events; and the instructions may be further configured to cause the processor to determine the personalized risk profile associated with the driver by evaluating the driver-related parameters with respect to a corresponding criterion for each of the one or more events, and the criteria for

the events may be specific to the driver group to which the driver is assigned. The features mentioned in this paragraph in combination with the twelfth example or the thirteenth example provide a fourteenth example.

[0018] According to various aspects, the instructions may be further configured to cause the processor to determine, for each risk factor, a respective weight representative of the influence of the risk factor on the risk score; and the personalized risk profile of the driver may further include the weights of the risk factors. The features mentioned in this paragraph in combination with any one of examples one to fourteen provide a fifteenth example.

[0019] According to various aspects, the instructions may be further configured to cause the processor to generate a textual representation of the risk factors and/or a textual representation of the risk scenario for the driver (e.g., including a risk rank within the driver group or a collective risk scenario); and cause a transmission of the textual representation of the risk factors and/or risk scenario to a user device communicatively coupled with the computer system. The textual representation of the risk scenario (and/or risk factors) may assist a user in setting or adjusting a simulation environment for training the driver. For example, a user may provide user-defined parameters defining the simulation environment according to the information derived from the textual representation of the risk scenario/risk factors. The features mentioned in this paragraph in combination with any one of examples one to fifteen provide a sixteenth example.

[0020] According to various aspects, the instructions may be further configured to cause the processor to: determine the risk score during a driving session of the driver as a real-time risk score; compare the real-time risk score with a predicted value of the risk score for the driving session; determine real-time driving-related instructions based on a result of the comparison; and cause a transmission of the real-time driving-related instructions to a user-device of the driver during the driving session. The features mentioned in this paragraph in combination with any one of examples one to sixteen provide a seventeenth example.

[0021] According to various aspects, the driving-related instructions may be configured to cause a visual representation of the real-time risk score to be displayed at the user device of the driver during the driving session. The features mentioned in this paragraph in combination with the seventeenth example provide an eighteenth example.

[0022] According to various aspects, a method for generating driving-related instructions may be provided, the method including: obtaining driving contextual data associated with a driver, wherein the driving contextual data are representative of driver-related parameters influencing

a driving performance of the driver; determining a personalized risk profile associated with the driver based on the driving contextual data, wherein the personalized risk profile includes a risk score associated with a driving-related risk for the driver and risk factors influencing the risk score; determining a risk scenario associated with the driver based on the personalized risk profile, wherein the risk scenario is representative of driving-related conditions causing an increased driving-related risk for the driver; and determining the driving-related instructions associated with the driver based on the personalized risk profile and on the risk scenario. The features mentioned in this paragraph provide a nineteenth example.

[0023] According to various aspects, the driving-related risk may include one or more events; and the method may further include determining the personalized risk profile associated with the driver by evaluating the driver-related parameters with respect to a corresponding criterion for each of the one or more events. The features mentioned in this paragraph in combination with the nineteenth example provide a twentieth example.

[0024] According to various aspects, the method may further include determining the personalized risk profile associated with the driver by comparing the driver-related parameters with a corresponding threshold for the one or more events or with a corresponding binary condition for the one or more events. The features mentioned in this paragraph in combination with the twentieth example provide a twenty-first example.

[0025] According to various aspects, the method may further include transmitting the generated driving-related instructions to a user device communicatively coupled with the computer system. The features mentioned in this paragraph in combination with the twentieth example or the twenty-first example provide a twenty-second example.

[0026] According to various aspects, the driving-related instructions may include vehicle instructions addressed to a vehicle driven by the driver and configured to prompt the vehicle to implement an autonomous functionality to reduce the driving-related risk associated with the driver. The features mentioned in this paragraph in combination with any one of examples nineteen to twenty-two provide a twenty-third example.

[0027] According to various aspects, the driver may be a driver of a commercial vehicle part of a fleet of commercial vehicles; and the driving-related instructions may include operator instructions addressed to an operator of the commercial fleet. The features mentioned in this paragraph in combination with any one of examples nineteen to twenty-three provide a twenty-fourth example.

[0028] According to various aspects, the operator instructions may be representative of a rostering for the commercial fleet including the driver. The features mentioned in this paragraph in combination with the twenty-fourth example provide a twenty-fifth example.

[0029] According to various aspects, the method may further include using the driving-related instructions (e.g., part of the operator instructions) to define one or more simulation parameters of a simulation environment for training the driver. For example, the method may include setting the simulation environment using the simulation parameters, or adjusting a user-defined simulation environment using the simulation parameters. The features mentioned in this paragraph in combination with any one of examples nineteen to twenty-five provide a twenty-sixth example.

[0030] According to various aspects, the method may further include defining the one or more simulation parameters based on the risk scenario for the driver. The one or more simulation parameters may define a simulation environment that reproduces the risk scenario identified for the driver, e.g. to provide a targeted training. The features mentioned in this paragraph in combination with the twenty-sixth example provide a twenty-seventh example.

[0031] According to various aspects, the driving contextual data include physiological data of the driver. The features mentioned in this paragraph in combination with any one of examples nineteen to twenty-seven provide a twenty-eighth example.

[0032] According to various aspects, the method may further include selecting one or more events; and assigning a respective weight to each of the selected events, and defining the driving-related risk for the driver as a weighted combination of the selected events. The features mentioned in this paragraph in combination with any one of examples nineteen to twenty-eight provide a twenty-ninth example.

[0033] According to various aspects, the method may further include assigning the driver to a corresponding driver group based on one or more driver characteristics represented by the driving contextual data associated with the driver. The features mentioned in this paragraph in combination with any one of examples nineteen to twenty-nine provide a thirtieth example.

[0034] According to various aspects, the method may further include determining the personalized risk profile for the driver according to the driver group to which the driver is assigned. The features mentioned in this paragraph in combination with the thirtieth example provide a thirty-first example.

[0035] According to various aspects, the driving-related risk may include one or more events; and the method may further include determining the personalized risk profile associated with

the driver by evaluating the driver-related parameters with respect to a corresponding criterion for each of the one or more events, and the criteria for the events may be specific to the driver group to which the driver is assigned. The features mentioned in this paragraph in combination with the thirtieth example or the thirty-first example provide a thirty-second example.

[0036] According to various aspects, the method may further include determining, for each risk factor, a respective weight representative of the influence of the risk factor on the risk score; and wherein the personalized risk profile of the driver further includes the weights of the risk factors. The features mentioned in this paragraph in combination with any one of examples nineteen to thirty-two provide a thirty-third example.

[0037] According to various aspects, the method may further include generating a textual representation of the risk factors and/or a textual representation of the risk scenario for the driver (e.g., including a risk score ranking within the driver group or a collective risk scenario); and cause a transmission of the textual representation of the risk factors and/or risk scenario to a user device communicatively coupled with the computer system. For example, the method may include setting/adjusting a simulation environment for training the driver based on the textual representation of the risk factors and/or risk scenario, e.g. by obtaining/defining simulation parameters based on the textual representation. The features mentioned in this paragraph in combination with any one of examples nineteen to thirty-three provide a thirty-fourth example.

[0038] According to various aspects, the method may further include determining the risk score during a driving session of the driver as a real-time risk score; comparing the real-time risk score with a predicted value of the risk score for the driving session; determining real-time driving-related instructions based on a result of the comparison; and transmitting the real-time driving-related instructions to a user-device of the driver during the driving session. The features mentioned in this paragraph in combination with any one of examples nineteen to thirty-four provide a thirty-fifth example.

[0039] According to various aspects, the driving-related instructions may be configured to cause a visual representation of the real-time risk score to be displayed at the user device of the driver during the driving session. The features mentioned in this paragraph in combination with the thirty-fifth example provide a thirty-sixth example.

[0040] According to various aspects, a computer program product may include instructions to cause the computer system of any one of the examples one to eighteen to execute the steps of the method of any one of the examples nineteen to thirty-six.

[0041] According to various aspects, a computer-readable medium having stored thereon the above computer program product is provided.

[0042] According to various aspects, a data processing apparatus configured to perform the method of any one of the examples nineteen to thirty-six is provided.

[0043] According to various aspects, a computer program element comprising program instructions, which, when executed by one or more processors, cause the one or more processors to perform the method of any one of the examples nineteen to thirty-six is provided.

[0044] According to various aspects, a computer-readable medium comprising program instructions, which, when executed by one or more processors, cause the one or more processors to perform the method of any one of the examples nineteen to thirty-six is provided. The computer-readable medium may include a non-transitory computer-readable medium.

BRIEF DESCRIPTION OF THE DRAWINGS

[0045] In the drawings, like reference characters generally refer to the same parts throughout the different views. The drawings are not necessarily to scale, emphasis instead generally being placed upon illustrating the principles of the invention. In the following description, various embodiments are described with reference to the following drawings, in which:

FIG.1A and FIG.1B show an illustrative representation of strategies for driver scoring and driver rostering;

FIG.2 shows a computer system for generating driving-related instructions, in a schematic representation according to various aspects;

FIG.3 shows an exemplary realization of a computer system for generating driving-related instructions, in a schematic representation according to various aspects;

FIG.4 shows exemplary driving contextual data, in a schematic representation according to various aspects;

FIG.5 shows a risk profiler in a schematic representation according to various aspects;

FIG.6A shows a schematic flow diagram of an event definition, according to various aspects;

FIG.6B shows an exemplary interface for event definition, according to various aspects;

FIG.7A shows a schematic flow diagram of a driver stratification, according to various aspects;

FIG.7B, FIG. 7C and FIG.7D show various aspects of driver stratification, according to the present disclosure;

FIG.8A shows a schematic flow diagram of risk assessment, according to various aspects;

FIG.8B shows exemplary driving contextual data for risk assessment, according to various aspects;

FIG.8C and FIG.8D illustrate various aspects of risk assessment, according to the present disclosure;

FIG.9 shows an interpolation to generate a risk model for an insufficient driver group, according to various aspects;

FIG.10 shows a risk simulator in a schematic representation according to various aspects;

FIG.11A and FIG.11B show aspects of the operation of an interpretation unit of the risk simulator, according to various aspects;

FIG.12 shows aspects of the operation of a simulation unit of the risk simulator, according to various aspects;

FIG.13 shows an operation advisor in a schematic representation according to various aspects;

FIG.14A, FIG. 14B and FIG.14C illustrate an exemplary configuration and operation of an advisory unit of the operation advisor in a schematic representation according to various aspects;

FIG.15A, FIG. 15B and FIG.15C illustrate an exemplary configuration and operation of a pre-rostering mapping unit of the operation advisor in a schematic representation according to various aspects;

FIG.16A, FIG. 16B and FIG.16C illustrate an exemplary configuration and operation of a rostering unit of the operation advisor in a schematic representation according to various aspects;

FIG.17A and FIG.17B illustrate an exemplary configuration and operation of a monitoring unit of the operation advisor in a schematic representation according to various aspects; and

FIG.18 shows a risk assessment system in a schematic representation, according to various aspects.

DESCRIPTION

[0046] Aspects described below in context of the method are analogously valid for the computer system, and vice versa. Furthermore, it will be understood that the aspects described below may be combined, for example, a part of one aspect may be combined with a part of another aspect.

[0047] It will be understood that any property described herein for a specific device may also hold for any device described herein. Furthermore, it will be understood that for any device described herein, not necessarily all the components described must be enclosed in the device, but only some (but not all) components may be enclosed.

[0048] In the framework of commercial vehicles, a safe operation may require that the drivers are aware of their risk scenarios, and further that the operators provide targeted countermeasures including training and rosters based on individual risks. Evaluation strategies exist in which a risk score for a driver is calculated from various parameters, e.g. using machine learning techniques, but such strategies are mainly applied for insurance pricing and generic driver performance rating, without a focus on defining targeted instructions for reducing a driving-related risk associated with the driver. Furthermore, strategies exist to provide advice to the operators of commercial vehicles for establishing a roster of drivers, but these strategies mainly rely on “basic parameters”, such as operational outcome or fatigue parameters.

[0049] In general, conventional approaches to risk evaluation in relation to commercial vehicles are usually based on a “coarse-grained approach” in which the drivers are considered as a whole, without taking into consideration the individual strengths and weaknesses of the drivers. Thus, the resulting evaluation is not only prone to a less fair performance evaluation, but also unsuitable for defining targeted advice to correct the behavior of a specific driver, because a countermeasure that may be valid for a driver with certain characteristics may be not applicable to a driver with other characteristics, and vice versa. Furthermore, a generalized evaluation may be biased towards the overrepresented driver group, thus resulting in a less fair performance evaluation.

[0050] **FIG.1A** and **FIG.1B** provide an illustrative representation of strategies for driver scoring and driver rostering, according to various aspects. In particular, **FIG.1A** and **FIG.1B** show a configuration 100a for driver scoring in which one or more machine learning (ML) models 102 are used to determine a driver score 104 (also referred to herein as risk score or driver risk score), and a configuration 100b for driver rostering (from fleet operators’ point of view) in which one or more optimization models 122 are used to determine a driver roster 124.

[0051] For driver scoring 100a, a predictive machine learning model 102 may receive, as inputs, various features 110 related to a driving scenario, such as information about the driver, information about the road conditions, information about the vehicle (e.g., type, maintenance status, etc.), information about the environment, and the like. Based on the input features 110 the machine learning model 102 may calculate a driver score 104 by evaluating a risk with respect to pre-defined events 112 that may occur in relation to driving, such as accidents as an example. In conventional approaches, the driver score 104 provided as output of the machine learning model(s) 102 may be used to define the price of an insurance policy 106, or to evaluate the generic performance of all drivers via a performance rating 108.

[0052] For example, insurance pricing and driving rating may be determined using machine learning and various data from the driver, road, environment, thus allowing to calculate both historical and real-time driver scores. As another example, a predictive model may assign a risk profile to determined geographic communities based on event information, e.g. taking into consideration common characteristics shared among risky drivers such as young age and driving risky vehicles. The relationship between accidents and driving scenarios using telematics data and driving behavior data may be analyzed to generate a risk profile under different driving modes (human, autonomous or hybrid).

[0053] For driver rostering 100b, optimization models 122 of different types may be employed, for example based on heuristic, based on optimization techniques with mixed integer programming (MIP), based on a reinforcement learning (RL) model, and the like. The optimization model(s) 122 may receive, as inputs various rostering-related features 130, for example describing the availability of the drivers, historical data on previous roster configuration, rules related to the operation of the fleet of commercial vehicles, and the like. The optimization model(s) 122 may determine the driver roster 124 based on the input features 130 with the aim of optimizing various parameters 132 (e.g., various key performance indicators, KPI), such as the operational costs, operational requirements 126, the fatigue level 128 of the drivers, basic performance of the drivers, and the like.

[0054] For example, an optimization model may be based on optimizing the operational outcomes and the fatigue level of workers to generate a roster. As another example, a driver schedule may be optimized by minimizing crash risk of drivers' working patterns combinations, which consists of work shift within the current and prior time window. As a further example, a crew member schedule may be optimized by reducing deviations from

operational constraints, which contain performance, work restrictions by laws and regulations, individual preference and attributes of the crew members.

[0055] The present disclosure is based on the realization that conventional approaches to driver scoring and driver rostering present several shortcomings that limit their efficiency in addressing driving-related risks in a targeted manner, and thus limit their efficiency in formulating targeted solutions.

[0056] With reference to FIG.1A and FIG.1B, in terms of driver performance evaluation or driver profiling, conventional approaches are mostly focused on quantifying driving safety via measures such as driver risk score 104. This value is often estimated by applying machine learning (ML) models 102 with historical accident records. Although it is useful for simple employee rating or insurance pricing, such risk score 104 alone is too abstract for drivers to decipher the condition under which they are prone to higher risks. As a result, it is difficult for both drivers to improve their performance and for operators to provide targeted advice. Moreover, there is a lack of clear explanations on how to make sure the driver score is fair and considers the heterogeneity among different drivers.

[0057] In this regard, aspects of the present disclosure may be based on the realization that a personalized assessment of a driver may provide a more accurate evaluation of possible risk scenarios, and thus may allow identifying targeted and more efficient countermeasures for that specific driver. Illustratively, conventional approaches do not duly take into account individual characteristics of a driver that may have an effect on driving-related risks. As an example, in a conventional approach a driving behavior may be considered “risky” or “aggressive” irrespective of the driver’s characteristics, such as level of experience, years of service, and the like. Illustratively, the labeling of a certain behavior may be based on unified thresholds (e.g., for speed, location, harsh acceleration or braking, fuel consumption, vehicle faults, etc.) that do not consider driver heterogeneity.

[0058] The approach proposed herein may instead include a personalized assessment of a driver, adapting the evaluation to driver-specific characteristics thus providing a more comprehensive and targeted assessment of driving-related risks. With the proposed approach, telematics features and their evaluation criteria (e.g., thresholds) may vary for different drivers, e.g. some older drivers may have a higher time-to-collision (TTC) threshold due to longer reaction time. The proposed strategy provides thus a deeper insight into the behavior of a driver and the risks connected thereto.

[0059] By way of illustration, in the proposed strategy the drivers are not taken as an abstract category with generic and common features (and no granularity), but the proposed approach may rather focus on the individual characteristics of each driver or group of drivers, to provide a targeted and personalized assessment of the risks, and provide a correspondingly targeted advice.

[0060] In various aspects, drivers may be grouped according to their specific characteristics, such as age, years of experience, chronic health conditions, and the like. The risk assessment based on a subdivision in groups rather than considering the drivers as a whole, allows capturing risk factors specific to a certain driver group, e.g. driving at night is more likely to be a risk factor for older drivers compared to younger drivers. The grouping allows different criteria (e.g., different thresholds or binary conditions) to be defined for the same feature, e.g. for an exemplary feature of “proximity to preceding object” a stricter criterion may be imposed to older drivers who tend to have longer reaction time, and thus allows evaluating a risk score for a driver in a more accurate manner. The grouping allows thus addressing a class imbalance, because different groups may have significantly different event occurrence, thus causing a non-driver specific model to be biased towards predicting the majority driver group. The targeted grouping described herein may thus increase the accuracy of the evaluation, by tailoring the assessment to the specific driver characteristics.

[0061] According to various aspects, the proposed approach may make use of real-time physiological data of a driver (e.g. stress, fatigue, etc.) for the risk assessment. Such type of data may be in some cases even more informative than telematics data, because real-time physiological data may allow evaluating an increase in the risk level even though the driving behavior of the driver does not show any significant variation yet. For example, a more experienced driver may not show any variation in the driving behavior despite having increased fatigue or stress levels, so that the risk of an accident may increase without the telematics data showing it.

[0062] In this context, the subdivision of the drivers into granular groups allows evaluating the physiological data in the context of the specific driver-characteristics and set appropriate criteria for assessing the driving-related risks for the driver. As an example, driver with more experience may have a higher tolerance for fatigue than novice drivers. As another example, driver with chronic condition may need higher sleep quality to operate at a similar risk level as compared to those without. The proposed approach takes into account intrinsic differences among drivers, thus providing a fairer and more accurate modeling.

[0063] According to various aspects, the proposed approach may include providing a personalized identification of risk scenarios for a specific driver. Illustratively, the proposed approach may use the driver-specific data to determine in which scenarios the driver may have increased driving-related risks. For example, a driver with reduced eyesight may be more risk-prone at night or along routes with reduced illumination. As another example, a driver with limited driving experience, may be more risk-prone along routes with complicated road geometry, etc. The personalization of the risk scenarios allows the generation of targeted advice to reduce the driving-related risks for the driver, thus providing an enhanced safety for the operation of the vehicle and further providing useful information for driver rostering (e.g., to provide driver-route-vehicle-shift combinations that reduce the overall driving-related risks).

[0064] As a further aspect, the present disclosure may be based on the realization that the driver scores alone are too abstract and do not allow the driver to understand in detail which characteristic/behavior may be responsible for a low score. Illustratively, a simple “score” does not show to the driver the areas in which improvements may be needed, so that targeted advice cannot be provided. In this regard, the proposed approach may include supplementing the risk score with corresponding risk factors that have an influence on the scoring. In the proposed approach a driver is not only made aware of a risk score, but also of which specific aspects (e.g., related to driving style, life style, road conditions, etc.) contribute to the definition of the risk score. Thus, the driver (and the operator) may identify relevant risk factors on which it may be possible to intervene for reducing the driving-related risk.

[0065] For example, events such as traffic accidents, vehicle breakdown and high fuel consumption are one of the major hurdles to achieve safe and efficient operation of commercial vehicles such as buses or delivery trucks. The proposed approach allows reducing or minimizing the occurrence of these events, by allowing a driver to clearly understand the driving conditions under which the individual driver is prone to significantly higher risks and further by allowing an operator to provide corresponding advice according to such conditions.

[0066] As a further consideration, driver profiling and rostering are conventionally addressed as separate problems, e.g. based on different input data, different models, with different optimization targets, etc. For example, in a conventional approach the optimization of a work schedule may be non-specific to drivers, thus not taking into consideration that for different drivers the optimization targets (e.g., the KPIs) may vary. From the fleet perspective, one of the most common ways to mitigate risk is by optimizing driver roster. In the optimization, conventional approaches mainly consider operational parameters and constraints such as driver

availability and overtime hours. However, other types of events that could also increase operation costs such as accidents are not well represented in the optimization objective. Therefore, risk scores and contextual factors from driver profiling are not properly incorporated in driver rostering.

[0067] Aspects of the present disclosure may be based on the realization that driver scoring and rostering are rather interrelated aspects of the same operation, and that the profiling of a driver may provide information to optimize the rostering. In this regard, the proposed approach may provide using driver-specific data and driver-specific risk scenarios for determining a driver roster for the operator.

[0068] The approach proposed herein may thus include providing detailed risk scenarios for different drivers, and defining targeted suggestions/training. Driver-specific contextual risk factors may be considered to tailor the assessment to the individual characteristics of the driver. At the operator-side, objectives/risk affecting operation costs such as accidents may be considered, and driver-specific events may be taken into account when defining a roster for the drivers. The proposed approach may thus improve the safety of commercial vehicle drivers and provide both the drivers and operators with advice such as rostering and targeted training plans. By applying the proposed strategy to drivers and potentially other types of transport workers with high-risk exposure, operators can provide a safer and more efficient working environment. At the operator-side this may improve their staff retention rate and business growth, as well as financial sustainability.

[0069] In the context of the present disclosure, the term “driver” may be used to describe a person (in other words, a human being) that drives a vehicle. In particular, the term “driver” may be used with reference to a driver of a commercial vehicle, but may in general describe a driver of any suitable driven vehicle. Further in particular, the term “driver” may be used with reference to a “professional driver”, i.e. to a person that is paid to drive a vehicle, but may in general describe also non-professional drivers. The term “driver” may describe a person that drives a vehicle both in the case that the person has full control over the vehicle, i.e. the driver may drive the vehicle without any assistance by an autonomous driving system of the vehicle, and/or in the case that the person is at least partially assisted by the autonomous driving system of the vehicle, for example the vehicle may implement automated functionalities such as setting the speed of the vehicle, carrying out a parking manoeuvre, controlling a headlight, etc. In general, the term “driver” may be used herein to indicate a person that is currently driving a

vehicle and/or a person that has driven a vehicle and/or a person that usually drives a vehicle (and for which driving-related data may be available).

[0070] In the context of the present disclosure, the term “vehicle” may be used to describe any suitable driven object. By way of example, a vehicle may include an engine configured to cause a motion of the vehicle, e.g. a combustion engine, an electrical engine, a hybrid engine, or any suitable type of engine. In a preferred configuration, for which the proposed strategy may be of particular relevance, the term “vehicle” may refer to a “commercial vehicle”. A “commercial vehicle” may be a vehicle that is used for commercial purposes, e.g. for offering a paid performance involving the commercial vehicle. It is however understood that, in principle, the proposed strategy may also be applicable to non-commercial vehicles. Furthermore, in a preferred configuration the term “vehicle” may refer to a “road vehicle”, i.e. a vehicle used for driving/transport on a road. It is however understood that, in principle, the proposed strategy may also be adapted for application to other types of vehicles (e.g., an aquatic vehicle, an air vehicle, and the like). As examples, a “vehicle” may include a car, a bus, a coach, a truck, a van, a motorcycle, an airplane, a boat, a manned drone, etc.

[0071] A “commercial vehicle” may be privately owned, or may be part of a “fleet” of commercial vehicles. The approach proposed herein may be of particular interest in relation to commercial vehicles that belong to a fleet, i.e. a commercial fleet, e.g. to provide targeted advice to the fleet operator. Thus, in the present disclosure particular reference may be made to commercial vehicles that are part of a fleet, illustratively commercial vehicles that are owned by a non-private entity, such as a company or an agency. Examples of commercial vehicles that belong to a commercial fleet may include buses or coaches for passenger transport, trucks for the transport of goods, trucks for the transport of livestock, taxicabs, trailers, and the like.

[0072] In this context, the term “operator” may be used to describe an entity that manages a fleet of commercial vehicles. The “operator” may be the entity that decides on the purchase, maintenance, replacement, dismissal, etc., of the vehicles of the fleet. Further, the “operator” may be the entity responsible for managing the drivers of the vehicles of the fleet, e.g. the entity responsible for defining the schedule for the drivers, for hiring new drivers, for training the drivers, etc. The term “operator” may thus describe a company, an agency, a department within a company or agency, a person within a company or agency, or any suitable entity responsible for managing a fleet of commercial vehicles (including the vehicles and the drivers of the vehicles).

[0073] In this context, the terms “roster” or “rostering” may be used herein with the meaning known in the art to describe the assignment of duties to the drivers of a commercial fleet, e.g. in a certain time period. “Rostering” may thus describe the planning and the allocation of tasks to the drivers of a commercial fleet. For example, a “roster” may specify which driver should drive a certain vehicle on a certain day, or which driver should travel along a certain route on a certain day or week, or which driver should take care of delivering certain goods, and the like. The terms “roster” or “rostering” may thus describe the organization and scheduling of the work related to a fleet of commercial vehicles, e.g. in terms of allocation of duties to the drivers.

[0074] The term “autonomous” in relation to a vehicle may be used herein to describe the capability of the vehicle to implement one or more functionalities (e.g., a variation of one or more driving parameters) without human input, illustratively without an input from the driver. An autonomous vehicle may be capable, for example, of braking, steering, changing speed, changing acceleration, changing trajectory, etc., without a direct input from the driver. A vehicle may be “fully” or “partially” autonomous. In general, an “autonomous vehicle” may operate both in an autonomous manner and under control from the driver. For example, a vehicle may implement autonomous functionalities in certain scenarios, e.g. in case of an immediate danger the vehicle may force the vehicle to stop, or may cause a change in trajectory, as examples. In the present disclosure the term “autonomous” may refer to vehicles in which part of the vehicle control is left to the driver, but it is understood that aspects of the present disclosure may apply also to “fully autonomous vehicles” that are capable of operating without a driver. In general, a vehicle capable of implementing at least one functionality in an autonomous manner may be considered as an autonomous vehicle or partially autonomous vehicle.

[0075] In the present disclosure reference may be made to a “user”. The term “user” may refer to an entity that makes use of the risk assessment methodology described herein. A “user” may be, for example, a user of a computer system configured to implement the risk assessment strategy described herein. The “user” may instruct the computer system to carry out the risk assessment, may provide inputs to the computer system, may receive outputs from the computer system, may select or adjust processing parameters, etc. In general, the term “user” may describe any entity that may use the risk assessment strategy described herein. For example, a “user” may be a driver carrying out a personalized risk assessment. In a preferred configuration, a “user” may be an operator of a commercial fleet carrying out a risk assessment

of one or more of the drivers belonging to the fleet or of one or more potential drivers for the fleet.

[0076] In the present disclosure reference may be made to a “user device”. A “user device” may be a communication device at the user-side that allows a communicative coupling with the computer system that determines the driving-related instructions. For example, a “user device” may be configured for wireless communication or wired communication. A “user device” may include any mobile or immobile communication device, such as a smartphone, a tablet, a laptop, a computer, or any suitable electronic device. In some aspects, a “user device” may be or include a vehicle driven by a driver. Illustratively, a “user device” may be part of a computer system of the vehicle driven by the driver.

[0077] In the present disclosure, the term “driving-related instructions” may be used to describe the output of a risk assessment process. The term “driving-related instructions” may thus describe any suitable type of targeted directive determined based on the risk assessment. The term “driving-related” may be used in this regard to broadly refer to relevant aspects associated with the driving of a vehicle. The term “driving-related” may thus refer to the actual driving of the vehicle, and further to other aspects that are related to the actual driving of the vehicle, such as a training of the driver, a rostering of a fleet of commercial vehicles, life habits of the driver, and the like. Furthermore, the term “instructions” may be used in this regard to broadly refer to any suitable type of information that may prompt adjustments to “driving-related” aspects, as will be described in further detail below. For example, a “driving-related instruction” may define specific actions to be executed, a sequence in which the actions should be executed, specific values for certain parameters, and the like. As another example, a “driving-related instruction” may have a more qualitative nature and provide in general an advice to be followed, e.g. by a driver or by an operator. A “driving-related instruction” may also be referred to herein as “driving-related advice”, “targeted instruction”, “targeted advice”, or simply as “advice”.

[0078] As mentioned, the strategy proposed herein may be of particular relevance for fleet management. In particular, the proposed approach may be easily incorporated with existing fleet management systems but with more emphasis on raising driver awareness on their risk scenarios and providing targeted advice. With ongoing social trends including the aging workforce and the growing adoption of electric vehicles (EVs) impacting this industry over the next 5 to 20 years, the proposed approach may prove increasingly valuable, particularly in

assisting older drivers during such transition period. It is however understood that, in principle, the proposed strategy may be also applied in different scenarios or for different applications.

[0079] As a further exemplary application, the proposed strategy may be applied to vehicle insurance pricing. Compared to conventional schemes utilizing driver score only, the proposed strategy may create additional value by providing more practical information such as personalized risk scenarios and driving advice to drivers. As a result of the potential reduction in accidents, the cost for both drivers and insurance companies may be lowered.

[0080] As a further exemplary application, the proposed approach may enhance existing driver or operator assistance solutions, such as Smart and Safety Connected Vehicle (SSCV) and Advanced driver assistance systems (ADAS) solutions. The enhancement includes the utilization of a more holistic range of data, the generation of more detailed and personalized risk scenarios with targeted advice, and the provision of a more intuitive and enhanced risk visualization. Particularly, ADAS solution equipped with the risk visualization proposed in this disclosure has the potential to benefit not just commercial vehicle drivers, but also drivers in general.

[0081] FIG.2 shows a computer system 200 in a schematic representation according to various aspects. In general, the computer system 200 may include a communication interface 202, a processor 204, and a memory 206. The memory 206 may be communicatively coupled with the processor 204, and may be configured to store instructions (e.g., software instructions, program code) executed by the processor 204. The instructions may cause the processor 204 to perform an adapted method 210 for generating driving-related instructions, described in further detail below. Aspects described with respect to a configuration of the processor 204 may also apply to the method 210, and vice versa. In an exemplary configuration the computer system 200 may be a server (e.g., may be a server computer). The method 210 may be a computer-implemented method. The processor 204 may also be referred to herein as processing circuit or processing circuitry.

[0082] It is understood that the operations caused by the instructions stored in the memory 206 may be implemented as a configuration of the processor 204, and vice versa. Illustratively, the processor 204 may be configured to carry out various functions described in relation to the instructions stored in the memory 206. In a corresponding manner, a functionality carried out by a component of the computer system 200 may correspond to a respective step of the method 210, and a step of the method 210 may correspond to a respective configuration of a component of the computer system 200 to carry out a functionality resulting in the method step.

[0083] It is also understood that the processor 204 may include a single processor (e.g., a single circuit) configured to carry out the method 210, or may include a plurality of processors (sub-processors, or sub-circuits) each configured to carry out a portion of the method 210. For example, a first (sub-)processor may carry out a first function related to the method 210, a second (sub-)processor may carry out a second function related to the method 210, etc. The various (sub-)processors may be communicatively coupled with one another, e.g. over a network.

[0084] In principle, in a configuration with a plurality of (sub-)processors, the individual (sub-)processors may belong to the same entity or may belong to different entities, e.g. the different (sub-)processors may be located in the same server or may be located in different servers disposed at different locations and communicate with one another over a network (e.g., the Internet). In particular, considering machine learning, a first (sub-)processor (e.g., belonging to a first entity) may be configured to carry out a training of a machine learning model, and a second (sub-)processor (e.g., belonging to a second entity) may be configured to carry out an inference phase using the trained model.

[0085] In some aspects, the memory 206 (also referred to as a “database”) may store input data and/or output data temporarily or permanently. In some aspects, the memory 206 may store program code which allows the computer system 200 to perform any one of methods described herein. In some embodiments, the program code may be embedded in a Software Development Kit (SDK). The memory 206 may include an internal memory of the computer system 200 and/or an external memory (e.g., the cloud). The external memory may include, but is not limited to, an external storage medium, for example, a memory card, a flash drive, and a web storage.

[0086] In some aspects, the communication interface 202 may allow one or more external systems to communicate with the processor 204, e.g. via a network 208. For example, the communication interface 202 may allow a communicative coupling between the computer system 200 and a user device. In some aspects, the communication interface 202 may transmit signals to the external systems, and/or receive signals from the external systems via the network 208. In some aspects, the communication interface 202 may receive information about driving contextual data associated with a driver, about rostering, etc. The network 208 may be any suitable communication network over which information may be transmitted/received, e.g. in form of data packets. As examples, the network 208 may include, but is not limited to, a Local Area Network (LAN), a Wide Area Network (WAN), a Global Area Network (GAN), or any

combination thereof. The network 208 may provide a wireline communication, a wireless communication, or a combination of wireline and wireless communication between the computer system 200 and external systems (e.g., user device(s)).

[0087] In general, the processor 204 may be configured (e.g., as part of the method 210) to carry out an adapted approach for generating driving-related instructions for reducing (e.g., minimizing) a driving-related risk. In this context, the expression “driving-related instructions” may describe any type of output suitable to prompt a certain action in relation to a process in which a driver drives (or will drive) a vehicle. As will be discussed in further detail below, a “driving-related instruction” may be addressed to the driver himself/herself, e.g. to prompt a change in the driving style, in his/her health habits, and the like. Additionally or alternatively, a “driving-related instruction” may be addressed to the driven vehicle, e.g. to cause the vehicle to implement a certain functionality in an autonomous manner. As a further example, additionally or alternatively, a “driving-related instruction” may be addressed to the operator of a commercial fleet, e.g. to assist with rostering and/or training of the drivers.

[0088] Further, in the context of the present disclosure the term “driving-related risk” may describe the likelihood of a potentially negative situation in relation to a process in which a driver drives (or will drive) a vehicle. A “driving-related risk” may thus be representative of the possibility that in relation to the driving of a vehicle by a driver, a potentially negative situation occurs. By way of illustration, a “driving-related risk” may be representative of the probability of the occurrence of a negative situation in relation to the driving of a vehicle by a driver. A (potentially) negative situation may encompass any type of circumstance, outcome, etc. that may be considered as undesired in the context of driving a vehicle. As examples, the “driving-related risk” may describe the likelihood of an accident or near-miss, of an increased fuel consumption, of an increased travel time, of damages to the vehicle, of injuries to the transported passengers or livestock, of injuries to the driver, of damages to the transported goods, of increased deterioration of vehicle components, and the like. A “driving-related risk” may also be referred to herein as “event risk”.

[0089] In general, a “driving-related risk” may include one or more events, e.g. a plurality of events. In this regard, the driving-related risk (event risk) may be representative of the probability of the occurrence or severity of a specific event or a weighted combination of multiple events in relation to the driving of a vehicle. The driving-related risk may thus be representative of the likelihood that a corresponding event or multiple events with a negative outcome may occur during a driving session, e.g. in a situation in which a specific driver drives

a vehicle. The driving-related risk may thus be representative of the likelihood of an individual event which undesirably affects a driving session, or of the likelihood of a combination of events that undesirably affect a driving session. As examples, an “event” may include an accident, a near-miss, a damage to a transported good, an injury to a transported passenger, and the like. For events that may incur significantly different cost with different severities such as accident, a weighted combination by severity may be implemented.

[0090] According to various aspects, the processor 204 may be configured to obtain (in other words, to get) driving contextual data 212 associated with a driver 214. As will be discussed in further detail below, the driving contextual data 212 may represent various parameters related to the driver and to a driving environment in which the driver 214 operates. As mentioned, in a preferred configuration the driver 214 may be a (professional) driver of a commercial vehicle, e.g. of a vehicle part of a commercial fleet. It is however understood that the aspects described herein may apply in general to any suitable type of driver in relation to the driving of any suitable type of vehicle.

[0091] The processor 204 may obtain the driving contextual data 212 in any suitable manner. As an example, the driving contextual data 212 may be stored in a database, and the processor 204 may (actively) retrieve the driving contextual data 212 from the database. For example, the memory 206 may store the driving contextual data 212, e.g. the database storing the driving contextual data 212 may be embedded in the memory 206, or partially embedded in the memory 206 and partially in an external storage (e.g., owned/managed by external entities). As another example, the processor 204 may receive the driving contextual data 212 via the communication interface 202, e.g. via the network 208, for example the processor 204 may receive the driving contextual data 212 from a user (e.g., from the operator of the commercial fleet) via a communicatively coupled user device. As another example, the processor 204 may receive at least part of the driving contextual data 212 directly from the driver 214, and/or from a computer system of the vehicle driven by the driver 214. As a further example, processor 204 may receive driving contextual data 212 (e.g., part of the driving contextual data 212) from external sources, illustratively from external entities (e.g., agencies, authorities) that are not directly part of a work-environment of the driver, i.e. entities other than the driver/vehicle/operator. The driving contextual data 212 may have any suitable format for processing by the processor 204, e.g. the driving contextual data 212 may include data packets organized according to a frame structure.

[0092] The driving contextual data 212 may be representative of driver-related parameters influencing a driving performance of the driver 214. In general, the driving contextual data 212 may include any suitable parameter that may affect the performance of the driver in relation to driving a vehicle. For example, the driving contextual data 212 (or at least part of the data 212) may be representative of driver-specific characteristics (also referred to as driver-specific features) that may be considered to have an impact or an effect on the capabilities of the driver in relation to driving a vehicle. The driving contextual data 212 (or at least part of the data 212) may thus be representative characteristics/features that are specific to the driver 214 under consideration. In general, the driving contextual data 212 may be representative of driver-specific quantities that have an influence on the driving performance of the driver. The driving contextual data 212 (or at least part of the data 212) may characterize the driver 214 in a personalized manner. Illustratively, the driving contextual data 212 may be driver-specific and driving-related data. The driving contextual data 212 may also be referred to herein as driving contextual parameters, driver-specific data, driver-specific parameters, or driver-specific information. Examples of possible driving contextual data 212 will be described in further detail in relation to FIG.4.

[0093] In this regard, the processor 204 may obtain (and analyse) different driving contextual data 212 when assessing different drivers 214. For example, the processor 204 may obtain first driving contextual data for assessing a first driver, second driving contextual data for assessing a second driver, third driving contextual data for assessing a third driver, etc.

[0094] Based on the driving contextual data 212, the processor 204 may determine (e.g., generate, build, construe) a personalized risk profile 216 associated with the driver 214. Illustratively, the processor 204 may use the driving contextual data 212 to create a personalized risk profile 216 for the driver 214. The personalized risk profile 216 may thus be a personalized driver-specific profile that represents an evaluation of that driver in relation to a driving-related risk, e.g. in relation to one or more risk events. An example of personalized risk profile 216 will be described in further detail in relation to FIG.11B. The personalized risk profile 216 may also be referred to herein simply as risk profile 216.

[0095] In general, the risk profile 216 may include a profiling of the driver 214 in terms of susceptibility of the driver 214 to certain risk factors that contribute to the driving-related risk for the driver 214. In this regard, the risk profile 216 may include a risk score associated with the driving-related risk for the driver 214 and risk factors influencing the risk score. Illustratively, the risk profile 216 may include a risk score representing an assessment of the

driver in relation to the driving-related risk, e.g. in relation to the events, and further the risk score may be enhanced by risk factors that contribute to the determination (e.g., the calculation) of the risk score. Any suitable number and/or type of risk factors may be considered, as will be discussed in further detail below.

[0096] By way of illustration, the risk profile 216 may be indicative of the proneness of the driver 214 to one or more events associated with driving. In this regard, the risk score may represent a general proneness of the driver 214 to the one or more events constituting the driving-related risk, and the risk factors may be factors that influence (e.g., increase) a degree (or level) of proneness of the driver 214 to the one or more events. In general, the risk score may be an individual score encompassing the driving-related risk, e.g. encompassing all the events considered for the risk assessment. In some aspects, however, the risk score may include a plurality of risk (sub-)scores, e.g. one (sub-) score for each event.

[0097] A “risk score” may be or include any suitable representation of the result of the assessment. For example, the risk score may be a number or a numerical representation of the degree of proneness of the driver 214 to a certain event or combination of events (e.g., a number on a scale from a minimum indicative of a low degree of proneness to a maximum indicative of a high degree of proneness). As another example, the risk score may be a letter or a string of letters that represent the degree of proneness of the driver 214 to a certain event or combination of events (e.g., “A” or “low” to indicate a low degree of proneness, and “Z” or “high” to indicate a high degree of proneness, with intermediate letters/strings between these two boundaries). As further examples, the risk score may be a percentage, a symbol, a color (e.g., represented on a display), a sound, or any other suitable way of representing the result of the evaluation carried out by the processor 204. It is understood that a representation in a scale from a low degree of proneness to a high degree of proneness is exemplary, and also other types of representation may be provided. As another example, the risk score may be provided with a representation in which a “higher value” of the risk score is indicative of a lower degree of proneness (and thus an overall “safer” situation in relation to that risk factor). In this alternative representation, a lower risk score may indicate a higher degree of proneness (and thus an overall “less safe” situation in relation to that risk factor).

[0098] According to various aspects, the processor 204 may be further configured to determine (e.g., generate, build, construe) a personalized risk scenario 218 associated with the driver 214 based on the personalized risk profile 216. Illustratively, the processor 204 may use the risk profile 216 to create personalized risk scenario 218 for the driver 214. The personalized risk

scenario 218 may be representative of a driver-specific scenario (or a plurality of driver-specific scenarios) in which the driving-related risk of the driver 214 may be higher. The personalized risk scenario 218 may thus be representative of driving-related conditions (e.g., time of day, type of route, type of vehicle, etc.) that cause an increased driving-related risk for the driver 214. For example, a risk scenario 218 may be representative of driving-related conditions in which the risk score for the driver is indicative of a higher driving-related risk (e.g., conditions in which the risk score has a greater numerical value, as an example).

[0099] In this regard, the driving-related risk represented by the risk scenario(s) 218 may be higher or increased with respect to a baseline driving-related risk, illustratively with respect to a reference driving-related risk or benchmark driving-related risk. In a preferred configuration, the baseline driving-related risk may be driver-specific (or specific for drivers that belong to a certain group), e.g. based on historical data or previous assessments. In some aspects, however, the baseline driving-related risk may have a common definition applied to all drivers. By way of illustration, the baseline driving-related risk may be the historical driving-related risk for the driver in case of the same or similar driving-related conditions (e.g., the average risk score for the past month when driving similar route under similar weather, similar number of hours of sleep, etc.). The personalized risk scenario 218 may thus be representative of driving-related conditions that cause an increased risk score with respect to a baseline risk score corresponding to the baseline driving-related risk.

[00100] For example, an increased driving-related risk may include the risk score showing a deviation from an average risk score in relation to certain events, e.g. a deviation from an average risk score calculated for a plurality of drivers, e.g. the drivers that belong to a certain group (see also FIG.7A to FIG.7D). In this configuration, the baseline driving-related risk may be an “average driving-related risk”, with an average over a plurality of drivers. The deviation may be, for example, a higher numerical value of the risk score when considering certain events, or may be any other suitable type of deviation depending on the representation of the risk score.

[00101] According to various aspects, the processor 204 may further determine (e.g., generate, define) driving-related instructions 220 associated with the driver 214 based on the personalized risk profile 216 and on the personalized risk scenario 218. Illustratively, the processor 204 may determine instructions 220 to reduce the driving-related risk associated with the driver 214 by assessing in which scenarios and due to which factors the driver 214 is prone to an increased risk. Stated in a different fashion, the driving-related instructions 220 may be

an “advice” on measures to implement to lower the driving-related risk for the driver 214, for example to obtain a driving-related risk for the driver 214 within a predefined range or below a predefined risk threshold. In this scenario, the events may be considered as the parameters to optimize (e.g., minimize), and the driving-related instructions 220 may be configured to reduce the likelihood of the occurrence of the events or to maintain the likelihood within a certain range.

[00102] As will be discussed in further detail below, the driving-related instructions 220 may include any suitable type of information for obtaining a low driving-related risk for the driver 214 (and correspondingly an improved risk score). As an example, the driving-related instructions 220 may include driver instructions that are representative of instructions addressed to the driver 214. For example, the driver instructions may be related to a behavior of the driver 214, e.g. in terms of hours of sleep, break times, sleep quality, and the like. Illustratively, the driver instructions may include a long-term or instantaneous advice to the driver 214 on what to change/adapt to reduce the driving-related risk (and improve the risk score).

[00103] As a further example, additionally or alternatively, the driving-related instructions 220 may include vehicle instructions that are representative of instructions addressed to the vehicle driven or to be driven by the driver 214. For example, the vehicle instructions may cause the vehicle to implement an autonomous functionality to reduce the driving-related risk. The vehicle instructions may cause the vehicle (illustratively, a computer system of the vehicle) to set or change any suitable vehicle parameter in an autonomous manner. For example, the vehicle instructions may cause the vehicle to set a maximum speed for the driver 214 and to prevent the driver 214 to drive above the set maximum speed. As another example, the vehicle instructions may cause the vehicle to increase the amount of light emitted by a headlight. As a further example, the vehicle instructions may cause the vehicle to prevent incoming phone calls from being taken by the driver 214. As another example, the vehicle instructions may cause the vehicle to set a maximum volume for an audio-reproduction system of the vehicle, etc.

[00104] As a further example, additionally or alternatively, the driving-related instructions 220 may include operator instructions that are representative of instructions addressed to the operator of a commercial vehicle driven or to be driven by the driver 214. For example, the operator instructions may be related to a training of the driver 214, e.g. indicating in which areas the driver 214 is in need of further training or specifying training parameters

designed for that driver. In this scenario, the operator instructions may represent one or more training parameters for carrying out a driving-related training of the driver. As another example, the operator instructions may be related to a rostering, e.g. indicating an appropriate allocation of duties to the driver 214, for example in combination with a plurality of other drivers.

[00105] As an example, the driver 214 may train his/her driving capabilities in a simulation environment. The simulation environment may be configured to mimic (in other words reproduce) a real-life driving situation, in which the driver 214 may practice in a safe manner. In a preferred configuration the simulation environment may be provided by a software, e.g., using an augmented reality or virtual reality system. It is however understood that the simulation environment may in principle also be a physical system (e.g., a closed track in which the driver may safely drive the vehicle while simulating real-life characteristics, e.g. a wet road, a crossroad, the presence of fog, etc.). In various aspects, the driving-related instructions 220 (e.g., as part of the operator instructions, for example as training instructions) may include one or more simulation parameters to define (e.g., set or adapt) the simulation environment for training the driver 214. The instructions 220 may illustratively indicate a suitable simulation to allow the driver to focus on his/her weaknesses, with the aim of improving the driver capabilities in relation to the most relevant or critical situations for the driver. The user (e.g., the operator, the driver) may set the simulation environment using the determined simulation parameters, or may adapt a previous user-defined simulation environment using the determined simulation parameters, and may carry out a training of the driver in the simulation environment set/adapted based on the determined simulation parameters.

[00106] According to various aspects, the processor 204 may determine the one or more simulation parameters based on the risk scenario 218 of the driver. Illustratively, having knowledge of the scenario 218 in which the driver 214 is at increased risk, the processor 204 may define simulation parameters to obtain a simulation environment designed for training the driver 214 in connection with the risk factors that contribute to the risk score. As an example, in case the risk scenario 218 includes driving at night on a road with many intersections, the simulation parameters may provide a simulation environment reproducing these conditions to allow the driver to practice more in potentially risky situations that are tailored to the specific driver. The processor 204 may determine/gather the simulation parameters (e.g., as training instructions) during the process, for example by mapping the simulation parameters to

corresponding simulation scenarios. In some aspects, the processor 204 may further cause a storing of the determined simulation parameters (e.g., in the memory 206) for further use or processing, e.g. as addition to an instruction knowledge database.

[00107] According to various aspects, the processor 204 may further cause a transmission of the generated driving-related instructions 220, e.g. to the driver 214, to a vehicle driven or to be driven by the driver 214, and/or to the operator. In general, the processor 204 may make the instructions 220 available to a user of the computer system 200. Illustratively, the processor 204 may transmit the driving-related instructions 220 to a user device communicatively coupled with the system 200. For example, considering the vehicle instructions, the processor 204 may cause the vehicle driven or to be driven by the driver 214 to receive and implement the vehicle instructions to control a (future) driving session of the driver 214, e.g. to set/change vehicle parameters according to the vehicle instructions. In some aspects, the processor 204 may further cause a transmission of the risk profile 216 (with risk scores and factors) and risk scenario(s) 218 to a user device, e.g. to the driver and/or operator.

[00108] The analysis carried out by the processor 204 may be carried out “offline”, illustratively while the driver 214 is not currently driving a vehicle, or “in real-time”, illustratively while the driver 214 is currently driving the vehicle. The “offline” analysis may be used for pre-driving estimation or post-driving review and the “real-time” analysis may be used during driving. In some aspects, the driving-related instructions 220 may thus be configured to prompt a real-time change in one or more parameters related to the driving. For example, the driving-related instructions 220 may cause the vehicle to set or change one or more vehicle parameters while the driving by the driver 214 is ongoing, e.g. a change in the speed or lane, in the light level, and the like. As a further example, the driving-related instructions 220 may be delivered in real-time to the driver 214 by any suitable means, e.g. an audio signal, a visual signal, etc., to prompt a corrective action from the driver during the current driving session. In some aspects, the driving contextual data 212 may include real-time data, for example real-time information about the vehicle, the route, the weather, etc. For example, the real-time data may include real-time physiological data of the driver while driving the vehicle, e.g. to assess a level of fatigue, a level of stress, etc.

[00109] In various aspects, the computer system 200 may further include an advice database (not shown) configured to store predefined driving-related instructions. Illustratively, the advice database may store a plurality of predefined driving-related instructions each associated with a corresponding risk scenario and/or risk profile. Each of the predefined

driving-related instructions may illustratively be mapped to a corresponding risk scenario (or profile). In this scenario, the processor 204 may be configured to retrieve one of the predefined driving-related instructions from the advice database for delivering, as output, the driving-related instructions 220. The processor 204 may use the risk scenario(s) 218 and/or risk profile 216 as keys to identify and retrieve the appropriate driving-related instructions in the advice database.

[00110] In case the advice database does not include any predefined driving-related instructions applicable to the risk scenario(s) 218 and/or risk profile 216 for the driver 214, the processor 204 may generate new driving-related instructions 220. In this case, the processor 204 may further cause a storing of the newly generated driving-related instructions 220 in the advice database, using the scenario(s) 218 and/or risk profile 216 as identifiers (keys) for the newly stored driving-related instructions 220. As will be discussed in further detail below, the processor may generate new driving-related instructions 220 in any suitable manner, for example based on a user-input (e.g., the user, for example the operator, may manually define the instructions), based on audio guidance during a driving simulation, based on generative models (e.g., machine learning models, for example using a neural network), and the like.

[00111] In general, the processor 204 may determine the risk profile 216 from the received data 212 and the risk scenario 218 from the risk profile 216 in any suitable manner, e.g. using any suitable algorithm, mathematical model, and like. In some aspects, the processor 204 may determine the risk profile 216 using a machine learning model that receives the driving contextual data 212 as input data and delivers the risk profile 216 as output data (e.g., after having determined the risk score and risk factors). In some aspects, the processor 204 may determine the risk scenario 218 using a machine learning model that receives the risk profile 216 as input data and delivers the risk scenario 218 as output data. Exemplary calculations of the risk score will be described in relation to FIG.8C. Illustratively, the processor 204 may be configured to apply a risk model for determining the risk score and risk factors associated with the driver 214. A “risk model” may define parameters, functions, relationships, etc. that “translate” the driving-related risk into a corresponding risk score and corresponding risk factors taking into account the driving contextual data of the driver 214. In this regard, a risk model may be any suitable mathematical model, e.g. a machine learning model or any other suitable algorithm.

[00112] In general, a “machine learning model” may have tunable parameters that may be adapted during a training phase based on training data (e.g., data representing known risk

scores, risk factors, risk scenarios, etc.). The processor 204 may apply the trained machine learning model during an inference phase to obtain as output the risk profile 216/risk scenario 218. A machine learning model may be trained and configured in any suitable manner, e.g. based on reinforcement learning, supervised learning, unsupervised learning, and the like.

[00113] In an exemplary configuration, a machine learning model used by the processor 204 for determining the risk profile 216/risk scenario 218 may include a neural network. The neural network may have any suitable configuration, e.g. modular neural network, convolutional neural network, recurrent neural network, generative adversarial network, feed forward neural network, and the like.

[00114] The approach proposed herein may thus provide an integrated system that helps both drivers understand their risk scenarios and operators generate a rostering plan considering holistic risks. The risk assessment for the driver is carried out with flexible risk definition and driver-specific high-risk scenario diagnosis. At the operator-side, the rostering integrates the aforementioned event risk, thus providing a targeted advice to improve the rostering based on the individual characteristics of the drivers.

[00115] The configuration of the computer system 200 enables an analysis of driver-specific risk scenarios by interpreting risk score and factors from profiling. This provides the possibility of generating targeted advice to operators and drivers covering rostering, driving, training and hiring, and the like. The computer system 200 may thus provide a wide range of advice that can help improve driver risk score and overall operation. Compared to conventional approaches, the computer system 200 may support a more flexible and holistic KPI definition, and allows to profile a driver 214 related to a driving risk and use the profile to generate schedule or roster. In the context of commercial vehicles, the proposed approach may improve the safety and efficiency of the drivers, of the passengers, of the transported goods, and of the other traffic participants.

[00116] The proposed approach may allow a holistic and flexible definition of risks including events that could lead to an increase of operation cost. The generation of driver-specific risk scenarios after analyzing a historical and real-time risk score allows providing corresponding recommendations to help drivers improve their risk scores. The proposed configuration may thus improve the driver performance by raising their awareness, and may enable a safer and more efficient working schedule.

[00117] In the context of FIG.2 the operation of the processor 204 is described in relation to a single driver 214. It is however understood that the risk assessment may be carried

out in parallel on a plurality of drivers. Illustratively, in some aspects, the processor 204 may be configured to receive driving contextual data associated with a plurality of drivers, and to carry out the profiling and assessment in parallel for the plurality of drivers.

[00118] As mentioned, in some aspects the processor 204 may be configured to carry out a grouping (stratification) of the driver(s) (see also FIG.7A to FIG.7D). In general, to determine the risk profile 216 associated with the driver 214, the processor 204 may evaluate the driver-related parameters with respect to a corresponding criterion for each of the one or more events defining the driving-related risk. Illustratively, the processor 204 may determine the risk score and risk factors for the driver 214 based on whether the driver-related parameters fulfill, for each event, a corresponding criterion. A “criterion” may also be referred to herein as “definition”. A “criterion” for the risk assessment may also be referred to herein as “assessment criterion” or “risk criterion”.

[00119] As an example, a criterion associated with an event may be a threshold, e.g. a numerical threshold. In this scenario, the processor 204 may evaluate the driver-related parameters/quantities with respect to a corresponding threshold for each of the one or more events defining the driving-related risk, or for a subset of the events defining the driving-related risk. A (numerical) threshold may be considered for events that are measurable by continuous indicators, such as speeding, etc. Only as an example, considering an event such as “speeding”, the processor 204 may take into consideration as driver-related parameter the driving speed, for example by comparing the speed values with corresponding reference (threshold) values indicative of a higher/lower risk associated with that event.

[00120] As another example, a criterion associated with an event may be a binary condition (also referred to herein as binary indicator), illustratively a yes/no condition. In this scenario, the processor 204 may evaluate the driver-related parameters/quantities with respect to a corresponding binary condition for each of the one or more events defining the driving-related risk, or for a subset of the events defining the driving-related risk. A binary condition may be considered for events for which a continuous value is not applicable or not fully descriptive, illustratively for events that are better represented by a yes/no (illustratively an on/off or 0/1) indication. A binary condition may be applicable to any type of event for which is relevant whether the event happened or not, such as “traffic light violation”, “accident at night”, “accident during daytime”, “injuries to passengers”, and the like. In this case the processor 204 may determine the risk score and risk factors for the driver 214 based on whether for such type of event an instance of that event occurred for the driver or not.

[00121] In this context, the grouping of the driver(s) may allow tailoring the criteria (e.g., the thresholds or binary conditions) for the assessment based on specific driver characteristics. Illustratively, rather than using general criteria for each driver, the processor 204 may evaluate the driver-related parameters with respect to criteria that are specific to the driver group to which the driver 214 belongs or to which the driver 214 has been assigned (in driver stratification, see FIG.7A to FIG.7D), e.g. specific thresholds or specific binary conditions. This may provide a fairer and more accurate assessment by considering for the driver 214 specific criteria that better reflect the actual scenarios and situations for the specific driver.

[00122] In case the processor 204 carries out a grouping of the driver(s), the processor 204 may be configured to apply a risk model specific for the driver group to which the driver belongs or to which the driver has been assigned. The group-specific risk model may be unique to that driver group, or may in general be a risk model adapted according to the specific characteristics of the drivers part of the driver group. Illustratively, a risk model associated with a (first) driver group may be different from a risk model associated with another (second) driver group, e.g. in a model parameter, a function, an exponent, etc.

[00123] Various additional aspects and possible implementations or realizations of the computer system 200 (e.g., of the processor 204) and of the method 210, e.g., of the driving contextual data 212, risk profile 216, risk scenario 218, and driving-related instructions 220, will be described in relation to FIG.3 to FIG.18.

[00124] **FIG.3** shows a risk assessment system 300 in a schematic representation, according to various aspects. The risk assessment system 300 may be an exemplary configuration of the computer system 200 (e.g., of the processor 204) described in FIG.2. As shown in FIG.3, the risk assessment system 300 may include a processor 304 (e.g., an exemplary configuration of the processor 204) that receives driving contextual data 312, generates a risk profile 316 and risk scenario 318 associated with a driver, and generates corresponding instructions 320 based on the risk profile 316 and risk scenario 318. It is understood that the aspects described in relation to the computer system 200 may apply in a corresponding manner to the risk assessment system 300, and vice versa. The computer system 200 and the risk assessment system 300 may also be referred to herein simply as system 200, 300.

[00125] According to various aspects, the system 300 may include a database 360 configured to store the driving contextual data 312. For example, the database 360 may be

configured to store driving contextual data 312 for a plurality of drivers (e.g., the drivers of a commercial fleet), and the processor 304 may obtain the driving contextual data 312 associated with a certain driver to carry out an assessment for that driver by retrieving the data from the database 360. The database 360 may be configured to collect event data, driver and contextual factors that could potentially affect event risk. The data is used for risk profiling and estimation. For example, the memory 206 described in relation to FIG.2 may store the database 360 or part of the database 360. In another exemplary configuration, additionally or alternatively, the processor 304 may receive the driving contextual data 312 over a communication interface. The system 300 may further include (as part of the processor 304) three general units (also referred to herein as modules). The arrows in FIG.3 indicate the flow of information among the components of the system 300.

[00126] The system 300 (e.g., the processor 304) may include a driver risk profiler 330 configured to receive the driving contextual data 312 and determine a risk profile 316 associated with the driver. Illustratively, the driver risk profiler 330 may be configured to determine risk score and risk factors by profiling the driver based on the driving contextual data 312. The driver risk profiler 330 may thus be the main sub-system responsible for driver risk profiling. As a difference with conventional approaches, the driver risk profiler 330 does not deliver, as output, as simple risk score, but also the risk factors (and in some aspects corresponding risk models), which are then used for generating a risk scenario (in risk simulator 340) and corresponding targeted advice (in operation advisor 350). In various aspects, the driver risk profiler 330 may be further configured to group/stratify drivers and assess risk of each group using the driving contextual data 312, as will be discussed in further detail in relation to FIG.7A to FIG.7D.

[00127] The system 300 (e.g., the processor 304) may further include a risk simulator 340 configured to receive the risk profile 316 from the risk profiler 330 and deliver, as output, a risk scenario 318 (or a plurality of risk scenarios) associated with the driver. The risk simulator 340 may be configured to make and evaluate risk scenarios using the influential risk factors 316 from the driver risk profiler 330. Illustratively, in some aspects the processor 304 (e.g., the risk simulator 340) may be configured to simulate a plurality of scenarios and identify one or more scenarios with an increased driving-related risk for the driver among the plurality of simulated scenarios to provide the risk scenario(s) 318 for that driver. During such process, the risk simulator 340 may also be used to gather feedback from operators or driving

instructors, and the feedback may then be added to the advice database and used in operator advisor 350.

[00128] In FIG.3 it is also shown an exemplary risk scenario 370. As discussed in relation to FIG.2, a “risk scenario” may in general be understood as a driving condition or combination of driving conditions under which the driver is prone to higher driving-related risk (higher event risk). In the exemplary case of FIG.3, the risk scenario 370 may include driving at night, driving through junctions and sharp turning and other vehicle-related conditions (not shown). Another example of the risk scenario in the context of commercial vehicle drivers will be discussed in relation FIG.11B where a rough rank of the driver is also included. The risk scenario may be personalized for the driver, but it is understood that more than one driver may have the same risk scenario (or very similar risk scenarios) especially when driver grouping is performed. Illustratively, a risk scenario 318, 370 may be an individual-level scenario associated with the individual driver to describe corresponding driving-related conditions for that driver that lead to an increased risk. Alternatively, a risk scenario 318, 370 may be a system-level scenario associated with a plurality of drivers (e.g., the drivers of the entire commercial fleet). The risk simulator 340 may determine the risk scenario 318, 370 by a collection of factors from driving environment that are influential to the increase of risk occurrence.

[00129] The operation advisor 350 may be configured to receive the risk profile 316 from the driver risk profiler 330 and the risk scenario(s) 318 from the risk simulator 340. The operation advisor 350 may be configured to generate driving-related instructions 320, illustratively a driving-related advice, based on the received risk profile 316 and risk scenario(s) 318. The operation advisor 350 may thus interpret the risk profile 316 and risk scenario 318 to obtain a targeted advice for the driver. In general, “targeted advice” may refer to targeted countermeasures based on corresponding risk scenario. In some aspects, the “targeted advice” may also be dependent on the driver group to which the driver is assigned.

[00130] In a similar manner as for the risk scenario, the targeted advice may in general be an individual-level advice with targeted instructions for an individual driver, or the targeted advice may be a system-level advice that takes into consideration a plurality of drivers (e.g., for rostering, training of a fleet, hiring advice, etc.).

[00131] As discussed in relation to FIG.2, the operation advisor 350 may provide different types of targeted advice during various phases of driving such as in relation to a hiring phase by offering hiring advice to the operator considering existing drivers or estimating a

candidate's risk group (indicated as hiring advice 328 in FIG.3). As a further example, the operation advisor 350 may provide targeted advice in relation to a pre-driving phase, e.g. pre-shift driving advice to generate optimal roster (indicated as rostering advice 324 in FIG.3). As a further example, the operation advisor 350 may provide targeted advice in relation to an on-driving phase, e.g. by visualizing real-time risk, predicting next-possible risk scenario and issuing corresponding driving advice 322. As a further example, the operation advisor 350 may provide targeted advice in relation to a post-driving phase, e.g. by providing post-shift driving advice, evaluating driver performance with risk score, and issuing training advice 326. Although not shown, the operation advisor 350 may further provide targeted advice directed to the vehicle itself, to adapt one or more vehicle parameters for a current driving session or in anticipation of a next driving session by the driver.

[00132] FIG.4 shows the details of driving contextual data 400 in a schematic representation, according to various aspects. The driving contextual data 400 may be an exemplary configuration of the driving contextual data 212, 312 discussed in relation to FIG.2 and FIG.3. According to various aspects, the driving contextual data 400 may include event data 410, driver data 420, route/environmental data 430, shift data 440, vehicle data 450, and telematics data 460. The type of data described in relation to FIG.4 have been found to provide an accurate and comprehensive assessment of the driving-related risk associated with a driver, illustratively types of data that represent parameters/quantities potentially influential to the event risk. It is however understood that in principle also additional, alternative, or less type of data may be considered for the risk evaluation. Illustratively, FIG.4 shows a possible configuration of a driving contextual data database (the database 360) configured to store driving contextual data 400.

[00133] In general, the driving contextual data 400 may include static data and dynamic data. The static data may be representative of static parameters that influence the driving performance of the driver, and the dynamic data may be representative of dynamic parameters that influence the driving performance of the driver. Illustratively, the static data may represent parameters or quantities that do not vary over time or that vary over a (much) longer timescale compared to the duration of a driving session. For example, the static data may represent parameters or quantities that do not vary over a period of time less than 12 hours, or less than 24 hours, or less than one week, as examples. The dynamic data may represent factors that vary over time on a timescale comparable to the duration of a driving session of

the driver. For example, the dynamic data may represent parameters or quantities that vary over a period of time less than 12 hours, or less than 24 hours, or less than one week.

[00134] Illustratively, within each data category, the data may be mapped to static and dynamic factors depending on how often such information is updated. For example, dynamic factors may be information that gets constantly updated within a relatively short period of time (e.g., within a day) such as ADAS alert, physiological data, and traffic volume. Static factors may be information that is not likely to get updated on a relatively short period of time (e.g., on a daily basis) such as accident occurrence, driver's age, route length, and the like. The data may be also divided in historical and real-time in operation. Historical data may be used, for example, for driver profiling (e.g., in risk profiler 330) and simulating driving environment (e.g., in risk simulator 340). Real-time data may be used for risk estimation and calculation (e.g., in operation advisor 350).

[00135] The driving contextual data database may be either hosted and managed in a central data location (e.g., owned by the operator of a commercial fleet) or distributed in several locations and managed by data owners (e.g., a plurality of operators). As an example, the driving contextual data 400 may be stored in distributed databases or in a blockchain. In general, the system 200, 300 may obtain (e.g., retrieve) the driving contextual data 400 from the storage location in which the data are stored (e.g., the memory 206). For example, a database configured to store the driving contextual data 400 may be designed as a dynamic relational database with primary keys such as driver ID, event ID and time.

[00136] The event data 410 may represent the events relevant for the driving-related risk. In this regard, the term "event" may refer to instances happening during operation that are observable and quantifiable, are influenced by factors from the driving contextual data database 400, and are directly or indirectly leading to the increase of operation costs. The event data 410 may include static data describing historical events, such as frequency of accidents, severity, related costs, etc. and may include dynamic data describing dynamically changing factors such as real-time alerts from an ADAS device, or fuel consumption. The event data 410 associated with a driver may originate, as examples, from historical records from operators or insurance company and real-time alert from an ADAS device. The event data 410 may represent a target to minimize, and may be used to formulate the dependent variable for risk profiling (e.g., the dependent variable of a risk profiling model), whereas the other types of data may be used to formulate the independent variables.

[00137] The driver data 420 may include parameters/quantities having an influence on the performance of the driver in terms of personal characteristics of the driver. In particular, the driving contextual data 400 may include (as part of the driver data 420) physiological data of the driver, illustratively data representing a state of the physical body of the driver. The driver data 420 may include static data describing slowly varying personal characteristics of the driver, such as age, experience, chronic health conditions, and dynamic data (e.g., real-time data) describing rapidly varying personal characteristics of the driver, such as fatigue level, acute health-related events (e.g., accelerated heartbeat, increased blood pressure, etc.).

[00138] The route/environmental data 430 may include parameters/quantities having an influence on the performance of the driver in terms of route, road or environmental characteristics, illustratively factors related to what the driver encounters along the travelled route. The route/environmental data 430 may include static data describing static characteristics of the route, such as length, road type, lane count, etc. and dynamic data describing dynamically varying characteristics of the route, such as traffic volume, weather conditions, and the like.

[00139] The shift data 440 may include parameters/quantities having an influence on the performance of the driver in terms of temporal or work-related factors, e.g. considering a driver of a commercial vehicle, illustratively of factors related to working conditions of the driver. The shift data 440 may include static data describing static or slowly varying characteristics of the working conditions, such as number of driving sessions per day, time of day during which the driver works, and the like. The shift data 440 may include dynamic data describing dynamically (and rapidly) varying characteristics of the working conditions, such as a current number of worked hours, whether the driver is working overtime, and the like.

[00140] The vehicle data 450 may include parameters/quantities having an influence on the performance of the driver in terms of vehicle-related factors, illustratively of characteristics (properties) related to the vehicle driven or to be driven by the driver. The vehicle data 450 may include static data describing static or slowly varying characteristics of the vehicle, such as type of vehicle, type of engine, maintenance history, etc. The vehicle data 450 may include dynamic data describing dynamically (and rapidly) varying characteristics of the vehicle, such as mileage, service time, passenger feedback (considering a vehicle for passenger transport), etc.

[00141] The telematics data 460 may include parameters/quantities having an influence on the performance of the driver in terms of monitoring of the vehicle. For example,

the telematics data 460 may include data from a Global Positioning System (GPS) of the vehicle, from an on-board diagnostics (OBD) of the vehicle, or from a vehicle Controller Area Network (CAN) bus. In general, the telematics data 460 are dynamic data and may include, for example, geographical coordinates of the vehicle (e.g., latitude, longitude), speed, steering, acceleration, distance from objects or traffic participants, and the like.

[00142] For example, the driver data 420 and vehicle data 450 may originate from an existing driver database from the commercial vehicle company's internal system, or directly updated by drivers through a user interface. The route data 430 and shift data 440 may be considered as spatial- and temporal-related data respectively. The route data 430 and shift data 440 may originate from external data sources such as traffic authorities or environment agencies.

[00143] In the following, with reference to FIG.5 to FIG.17B, the various functions carried out by the computer system 200 and risk assessment system 300 will be described in further detail. Illustratively, FIG.5 to FIG.17B provide a detailed description of possible configuration of the risk profiler 330, risk simulator 340, and operation adviser 350. In the figures, rectangles represent function units. Rectangles with rounded corners represent input/output or intermediate input/output.

[00144] **FIG.5** shows a risk profiler 500 in a schematic representation according to various aspects. The risk profiler 500 may be an exemplary configuration of the risk profiler 330 of FIG.3. It is understood that the aspects discussed in relation to the risk profiler 500 (and its components) may apply in general to the risk profiler 330 and to a configuration of the processor 204, 304, and vice versa.

[00145] In general, the risk profiler 500 may be configured to determine a personalized risk profile for the driver based on the driving contextual data. In various aspects, the risk profiler 500 may generate the risk profile according to three main sub-functions, namely event definition 510, driver grouping 520 (also referred to herein as driver stratification), and risk assessment 530. Each function may be implemented by a corresponding unit or module of the risk profiler 500, illustratively, an event definition unit 510 (EDU), driver stratification unit 520 (DSU), and risk assessment unit 530 (RSU). The event definition unit 510 may be configured to carry out definition of events, e.g. by selecting relevant events and assigning corresponding weights. The driver stratification unit 520 may be configured to carry out driver stratification, e.g. grouping drivers by significant features based on the defined

events and driver data. The risk assessment unit 530 may be configured to determine risk score, risk factors, and in some aspects risk models/functions for the driver, e.g. for each driver group.

[00146] According to various aspects, the risk profiler 500 (e.g., as part of the event definition 510) may be configured to define the type of events relevant for the driving-related risk for the driver. Illustratively, the event definition unit 510 may be configured to select one or more events that are indicative of a driving-related risk, and to assess the driver with respect to the selected events. For example, the event definition unit 510 may be configured to select the events associated with the driving-related risk based on event data 502 of the driving contextual data (e.g., the event data 410).

[00147] The event definition unit 510 may deliver, as output (and input to the driver stratification unit 520) an event risk 512 based on the selected events. The event definition unit 510 may thus define the event risk 512 used for driver risk profiling. The event risk 512 may be defined, for example, as the occurrence of one event or the weighted combination of multiple events. Illustratively, the event risk 512 may be provided as one or more events with a negative impact on the driving or events that indicate potentially negative situations. The event definition unit 510 may thus determine (e.g., define, calculate) the event risk 512 in relation to individual events or as a combination of one or more of the selected events.

[00148] For example, events that may be considered for defining the event risk 512 may include accidents, near-miss, injuries caused, damages caused, increased fuel consumption, security alerts (e.g., ADAS alerts), and the like. In principle, the profiling may be based on any suitable type of risk-related events and on any suitable number of risk-related events. In some aspects, the event definition unit 510 may select, for a certain driver, a subset of events from a pool of possible (relevant) events. Illustratively, the event definition unit 510 may limit the further assessment to only some types of events considered to be most relevant for the scenario at hand. As an exemplary configuration, the event definition unit 510 may decide which event types to select by analyzing the main events causing increased operation cost in the previous planning cycle. The selection of the events may thus limit the driving-related risk/event risk against which the driver is evaluated. In some aspects, the event definition unit 510 may thus determine the event risk 512 as a combination of a subset of event types from a pool of possible event types.

[00149] According to various aspects, the event definition unit 510 may be further configured to assign a weight to each of the events, e.g. to each of the selected event types, for defining the event risk 512. In case more than one event type is considered for risk profiling,

the event definition unit 510 may define different weights for different events when determining the event risk 512, e.g. according to a respective relevance for the driver (or for the operator). For example, the event definition unit 510 may assign weights that correspond to a greater contribution in determining the event risk 512 to events that cause more serious damages. Given some event types such as accidents may have different severity levels, the system may allow such events to be weighted by severity when calculating event risk 512. For example, a fatal accident and injury accident may be weighted more heavily than a property-damage-only accident and near-miss. The weight may be inferred based on their corresponding operation and/or insurance cost. The event definition unit 510 may thus determine the event risk 512 as a weighted combination of the events, e.g. of the selected event types.

[00150] For example, if more than one event type is selected, weightage of different event types may be assigned based the cost they have incurred. Those event types that caused higher costs may be given higher weightages so that factors contributing to that are more likely to be represented in the profiling of the driver. As another example, an operator may choose to modify the definition of events from a user interface.

[00151] According to various aspects, the risk profiler 500 (e.g., as part of the driver stratification unit 520) may be configured to assign the driver to a corresponding driver group based on the driving contextual data associated with the driver, for example based on driver data 504 (e.g., the driver data 420). Illustratively, for the determination of the risk profile, the driver stratification unit 520 may be configured to identify one or more driver characteristics, and to assign the driver to a corresponding driver group based on the one or more driver characteristics.

[00152] The grouping will be described in further detail in relation to FIG.7A to FIG.7D. In brief, the driver stratification unit 520 may provide a stratification of the drivers, e.g. of drivers belonging to a commercial fleet, by dividing the drivers according to the respective driver characteristics. The grouping/stratification enables a more tailored assessment of the risk for the driver, by considering the peculiarities of the respective group when determining the risk score and risk factors in relation to the (selected) event types contributing to the event risk 512.

[00153] By way of illustration, the driver stratification unit 520 may be configured to group drivers that share common traits (e.g., a common risk profile) in order to ensure a fair risk evaluation. The main benefit of stratifying drivers prior to risk assessment may be threefold. First, different driver groups may have different risk factors by nature. For example,

a long route length is more likely to be a risk factor for older drivers or drivers with certain health conditions compared to their younger counterpart or those without such conditions. By analyzing the entire drivers as a whole, such specific risk factors may not be captured. Second, even for the same factor, the same definition or encoding may not always be appropriate. For instance, when defining one of the most common factors “improper speed”, a higher speed threshold may be more reasonable for drivers with more experience compared to less experienced drivers since it may be less risky for the former to drive at the same speed due to their adeptness. Third, because of the more precise feature capture and definition, a higher accuracy of the subsequent risk modelling may be provided.

[00154] The driver stratification may be of particular relevance when assessing a driver with respect to his/her telematics characteristics and/or physiological characteristics. These type of data may be particularly susceptible to variations among drivers, so that a granular definition of criteria (e.g., thresholds or binary conditions) for the risk assessment in relation to such type of data may allow a fairer and more precise evaluation of the driver.

[00155] In principle, the grouping may be based on any suitable driver characteristics (also referred to herein as driver feature(s)). In a preferred configuration, the driver stratification unit 520 may be configured to define driver groups based on intrinsic driver characteristics (illustratively, static driver data), and to assign the driver under assessment to a respective driver group according to intrinsic driver characteristics 504a. For example, the driver stratification unit 520 may determine how to group the drivers by analyzing the relationship between event risk 512 and the intrinsic driver features 504a, e.g. using statistical analysis or machine learning algorithms. The intrinsic driver features 504a may be extracted from static driver data such as age, years of experience, chronic health condition, and the like. Through the analysis, key features that significantly differentiate event risk 512 may be identified. For continuous factors, the thresholds may be automatically defined by models such as decision tree. Similar to the aspects discussed in relation to the event definition unit 510, the driver features and their definitions may be modifiable by users (e.g., by an operator). Based on user-confirmed settings, the original dataset may be split into mutually exclusive data groups 522 that collectively form the original dataset.

[00156] The driver stratification unit 520 may deliver, as output, a driver group 522 to which the driver belongs. The output of the driver stratification unit 520 may be the input of the risk assessment unit 530. In some aspects, the driver stratification unit 520 may deliver, as

output, a plurality of driver groups, each including one or more drivers, to carry out the risk assessment for the plurality of drivers in parallel.

[00157] According to various aspects, the risk profiler 500 (e.g., as part of the risk assessment unit 530) may be configured to carry out a risk assessment to determine the risk profile for the driver, e.g. the respective risk score and risk factors. Considering the grouping, the risk assessment unit 530 may be configured to determine the risk profile based on the driver group to which the driver has been assigned. Illustratively, the risk assessment unit 530 may carry out driver risk profiling by generating a risk estimation model using historical data from each driver group stratified in the driver stratification unit 520 for risk score estimation and risk factors identification.

[00158] In some aspects, the risk assessment unit 530 may be further configured to define a risk model for the driver. The “risk model” may be any suitable type of model that allows an assessment of the driver in relation to the event risk 512 based on the risk profile (and risk scenario) of the driver. As an exemplary configuration, the risk assessment unit 530 may apply supervised learning algorithms for risk assessment for each driver group. The risk assessment unit 530 may determine the risk profile based on the driving contextual data. For example, with reference to the exemplary configuration in FIG.4, the risk assessment unit 530 may determine the risk profile based on telematics data 524, route data 526, shift data 528, vehicle data 532, driver data 504 (e.g., extrinsic driver data 504b, and excluding the intrinsic driver data 504a features used by the driver stratification unit 520), or any combination thereof.

[00159] Illustratively, the risk assessment unit 530 may extract predictors from the driving contextual data (e.g., from the driving contextual data database 400), or two-way interaction terms between these features. The outcome of the assessment is a transformed event risk, illustratively a personalized event risk for a specific driver (belonging to a specific driver group).

[00160] The risk assessment unit 530 may transform the event risk 512 into a (personalized) risk score for the driver, e.g. based on the characteristics of the driver group to which the driver belongs. As an exemplary configuration, considering that event risk 512 may be defined by event occurrence (a non-negative integer value with no upper bound), one way to transform it into a risk score (e.g., in case of an exemplary numerical representation a value from lowest risk 0 to highest risk 100) may be via simple mathematical functions as shown in Equation (1):

$$\text{Risk score} = 100 \times (1 - a^x), \quad 0 < a < 1 \quad (1)$$

[00161] The coefficient “ a ” may be determined in any suitable manner, for example by asking operators to define the event occurrence within the sampled time period for a driver to be considered as acceptable (e.g., scored 60). Considering the exemplary case in which the acceptable event occurrence is 2, then the coefficient equals to the squared root of 0.6.

[00162] Example risk models for risk assessment may include regression models such as multiple linear regression and tree-based regression depending on the formulation of event risk and model accuracy. There may be some cases where the sample size of one driver group may be insufficient for a meaningful ML model. In that case, a risk model for that insufficient driver group may be generated by interpolating from adjacent driver groups with sufficient sample size (see also FIG.9). For example, if drivers aged between 51 and 60 were an insufficient group, the risk model for this group may be interpolated by aggregating the models from drivers aged no more than 50 and above 60. Illustratively, in some aspects the risk assessment unit 530 may be configured to determine the risk profile for a driver belonging to a certain driver group via an interpolation of risk profiles of driver belonging to different driver groups, e.g. adjacent driver groups in terms of a driver characteristic (e.g., age.).

[00163] After performing model selection, influential features included in the final parsimonious model are defined as risk factors for each driver group. The risk assessment unit 530 may deliver two outputs, a first output 534 may include risk score, risk factors, feature importance and the model coefficients used for calculating risk score and may be delivered to the risk simulator. A second output 536 may include risk score, risk factors and risk model used for the assessment and may be delivered to the operation advisor for advice generation.

[00164] The functionalities of the risk profiler 500 will be described in further detail in relation to FIG.6A to FIG.9. Illustratively FIG.6A to FIG.9 show exemplary configurations for the operation of the event definition unit 510, driver stratification unit 520, and risk assessment unit 530.

[00165] **FIG.6A** shows a schematic flow diagram of an event definition 600, according to various aspects. Illustratively, the event definition 600 may be an exemplary configuration of the event definition unit 510, e.g. the event definition unit 510 may be configured to carry out the (steps of) event definition 600. As mentioned, the purpose of the event definition is to define (in other words, select, identify) the events to monitor for the risk profiling of the driver.

[00166] The event definition 600 may include, in 610, defining the event types according to a predefined criterion (also referred to herein as “event definition criterion), for

example, the event definition 600 may include identifying the event types that drove operational costs in the previous planning cycle. This criterion may be of particular relevance for operators of commercial fleets, but it is understood that in principle the event definition 600 may be based on any suitable event definition criterion for identifying relevant event types for the risk assessment.

[00167] The event definition 600 may include, in 620, assigning weights to the defined event types. The weight assignment may be based on any suitable weight assignment criterion. In a preferred configuration, the event definition 600 may include assigning weights to the event types based on the respective relevance for a driving-related risk for the driver, e.g. based on the respective influence on (potentially) negative outcome or scenario associated with driving of a vehicle.

[00168] For example, the event definition 600 may include auto-filling the weights by analysing the contribution of each type of events to operation costs in the previous planning cycle (e.g., from a financial report of the fleet operator). Based on the quantified influence, higher weights may be given proportionally to more influential events. In this regard, FIG.6B shows an exemplary interface 650 for defining events.

[00169] The interface 650 may include a first field 652 indicating different event types, e.g. accident or near-miss, vehicle breakdown, fuel consumption, or any suitable event type that may be of relevance. The interface 650 may further include a second field 654 indicating whether the event type is severity-weighted, illustratively to indicate whether the event frequency is weighted by severity. For example, fatal accidents may be weighted heavier than injury accidents. As an exemplary data source, such weights may be obtained from literature or insurance cost. The interface 650 may further include a third field 656 indicating the weight assigned or to be assigned to a certain event type. The interface 650 may be a user interface via which a user may control the event definition, e.g. by indicating which event type to consider, by adjusting the respective weights, and the like.

[00170] Going back to the event definition 600 in FIG.6A, the event definition 600 may further include, in 630, checking whether the user confirmed the event types and weights. This step may be optional in the event definition 600 in case user interaction is desired. In other aspects, the event definition 600 may proceed in an automatic manner without waiting for a user input/confirmation on the event types and weights. For example, a user (e.g., an operator) may select predefined event types and weights to be used for each risk assessment, so that the user confirmation is not necessary for each new evaluation. As another example, the event

definition 600 may prompt a user periodically to confirm the event types and weights, e.g. to ensure that the process is running according to the expectations of the user.

[00171] After the event types have been selected, and the weights have been assigned to the event types, the event definition 600 may include, in 640, proceeding to the subsequent stage of the risk profiling. For example, the event definition 600 may include delivering to the driver stratification unit the (selected) event types and corresponding weights, e.g. delivering an event risk based on the (selected) event types and corresponding weights to the driver stratification unit.

[00172] **FIG.7A** shows a schematic flow diagram of a driver stratification 700, according to various aspects. Illustratively, the driver stratification 700 may be an exemplary configuration of the driver stratification unit 520 to carry out driver grouping/driver stratification. Illustratively, the driver stratification unit 520 may be configured to carry out the (steps of) driver stratification 700. As mentioned, the purpose of the driver stratification is to identify significant driver features that differentiate event occurrence to divide the drivers into subgroups for fitting into different models for the risk assessment (e.g., in the Risk Assessment Unit (RAU)).

[00173] In general, the stratification of the driver into a respective driver group may be an optional step in the risk assessment. The driver stratification may enhance the targeting of the risk assessment and of the advice generation, but it may be dispensed with in some scenarios, e.g. in case the number of drivers to analyze is limited. The driver stratification 700 may thus include, in 710 determining whether the driver stratification should be performed. If the driver stratification is not necessary/desired for the driver under consideration, the driver stratification 700 may terminate and proceed directly to the risk assessment 760.

[00174] If the driver stratification should be performed, the driver stratification 700 may proceed to 720, and may include identifying significant driver characteristics (driver features) for assigning the driver to a respective group. As mentioned, the significant driver characteristics may be any suitable characteristic descriptive of the driver, for example any suitable intrinsic characteristic of the driver such as age, chronic health conditions, and the like. Other suitable characteristics may include, for example, number of accidents over a certain time period (e.g., over 1000 driven hours, as an example), years of experience, and the like.

[00175] In 720, the driver stratification 700 may further include identifying corresponding assignment criteria for the grouping, e.g. corresponding ranges (with associated thresholds, e.g. lower and upper thresholds) against which the driver characteristics may be

compared to assign the driver to a corresponding group. Illustratively, the driver stratification 700 may include determining (e.g., selecting, adjusting) the assignment criteria for determining to which group the driver may be assigned according to the specific driver characteristics. An “assignment criterion” may also be referred to herein as “stratification criterion” or “grouping criterion”.

[00176] In general, any suitable approach may be used for driver stratification. As an example, the driver stratification 700 may include running a supervised learning model or a statistical analysis for identifying the driver characteristics and associated assignment criteria.

[00177] The driver stratification 700 may further include, in 730, checking whether the user confirmed the identified driver characteristics and assignment criteria. This step may be optional in the driver stratification 700 in case user interaction is desired. In other aspects, the driver stratification 700 may proceed in an automatic manner without waiting for a user input/confirmation on the driver characteristics and assignment criteria. User definition may introduce “gaps” in user groups, which may be taken care of in the risk assessment unit.

[00178] If the user does not approve the driver characteristics and assignment criteria, the driver stratification 700 may proceed to 740 and modifying (e.g., updating) the identified driver characteristics and assignment criteria according to an input from the user, e.g. according to specifications defined by the user.

[00179] The driver stratification 700 may further proceed to 750, either directly with the driver characteristics and assignment criteria identified in 720 or with the modified/updated version specified by the user. In 750, the driver stratification 700 may include assigning the driver to a corresponding driver group based on the identified driver characteristics and according to the identified assignment criteria, e.g. the identified ranges. Illustratively, the driver stratification 700 may include grouping the driving contextual information of the driver with the driving contextual information of a plurality of other drivers.

[00180] After drivers have been assigned to respective driver groups, the driver stratification 700 may include, in 760, proceeding to the subsequent stage of the risk profiling. For example, the driver stratification 700 may include delivering to the risk assessment unit the grouped data associated with the driver.

[00181] **FIG.7B** shows an exemplary grouping 702, e.g. an exemplary outcome of the driver stratification 700. In the exemplary configuration in FIG.7B, the grouping 702 may include two driver characteristics, namely accident history 704 and age 708, but it is understood that any suitable number of driver characteristics may be considered. The grouping 702 may

further include, for each characteristic, corresponding assignment criteria, e.g. corresponding ranges with related thresholds (illustratively, boundaries). In this regard, any suitable number of assignment criteria may be considered for the grouping. In the exemplary case in FIG.7B, the grouping 702 may include two ranges 706-1, 706-2 for the first characteristic 704, e.g. a first range 706-1 including 0 accidents and a second range 706-2 including any number of accidents greater than 0. Further, the grouping 702 may include three ranges 712-1, 712-2, 712-3 for the second characteristic 708, e.g. a first range 712-1 up to 45 years of age (with “45”, included, as upper threshold), a second range 712-2 from 45 years of age to 65 years of age (with “45”, excluded, as lower threshold and “65” as upper threshold), and a third range 712-3 from 65 years of age.

[00182] The driver stratification 700 allocates each driver to a corresponding group. In the exemplary case in FIG.7B six different groups are defined by the selected number of characteristics and ranges. With the grouping, considering a sample of 100,000 drivers, instead of fitting the total 100,000 data to an aggregated model in the main profiling unit in the subsequent step, 6 models will be fitted. The stratification may thus simplify the subsequent analysis, in addition to providing a more tailored risk assessment for the drivers.

[00183] FIG.7C shows exemplary data used for modeling after performing the driver stratification 700 (e.g., in the DSU 520). The exemplary data in FIG.7C refers to the exemplary characteristics and ranges/thresholds of FIG.7B, but it is understood that the aspects discussed in FIG.7C may apply in a corresponding manner to different relevant driver characteristics and corresponding assignment criteria.

[00184] As shown in FIG.7C, the driver stratification 700 may include considering different drivers, e.g. identified via a unique driver ID 714, in relation to the selected relevant characteristics 704, 708. Illustratively, the driver stratification 700 may include determining (e.g., obtaining, calculating) for each characteristic 704, 708 a corresponding value or quantity associated with the driver. For example, the first driver AB may be 40 years old and with 0 accidents, the second driver RA may be 38 years old and with 0 accidents, etc.

[00185] As shown, based on the values associated with the driver, the driver stratification 700 may assign the driver to a respective group and indicate a respective risk model 724 to be used for the risk assessment in relation to that driver, e.g. a respective risk model specifying criteria (e.g., thresholds, binary conditions) to be used to evaluate the driver with respect to the selected events defining the driving-related risk. For example, driver AB

and RA are included in the same group with a model label “1” for subsequent risk modelling using other factors 722 excluding the characteristics currently used for the stratification.

[00186] **FIG.7D** shows an exemplary procedure 770 for driver stratification unit 520. It is understood that the procedure 770 in FIG.7D is only an example and in general any suitable interface or graphic user interface may be provided.

[00187] The procedure 770 may include an exemplary automatic process for deciding the stratification criteria according to event risk. As shown, in various aspects, a model 778 may be configured with event frequency as outcome and intrinsic driver characteristics as features. Assuming a tree model 776, the influential factors and their feature importance can be visualized in 774. It is however understood that other types of visualization of the grouping and other types of grouping algorithms may be provided.

[00188] The procedure 770 may further include an input interface 772 to allow the user to provide inputs for the outcome of the automatic driver stratification 700. The input interface 772 may offer to the user the possibility to define the grouping criteria, in terms of characteristics to be considered and related ranges/thresholds.

[00189] **FIG.8A** shows a schematic flow diagram of risk assessment 800, according to various aspects. Illustratively, the risk assessment 800 may be an exemplary configuration of the risk assessment unit 530, e.g. the risk assessment unit 530 may be configured to carry out the (steps of) risk assessment 600. As mentioned, the purpose of the risk assessment 800 may be driver profiling. The risk assessment 800 may generate (or retrieve) a risk estimation model from historical data for driver score calculation and identify risk factors for (subsequently) constructing risk scenarios for the driver.

[00190] As shown in FIG.8A, the risk assessment 800 may include, in 810, receiving the data from the driver stratification unit, e.g. grouped data or individual driver data depending on whether the driver stratification was performed. The risk assessment 800 may further include, in 820, applying a risk model (also referred to herein as risk assessment model) to obtain for each driver (or each driver group) corresponding risk score and risk factors. As discussed in relation to FIG.2, the risk assessment 800 may use any suitable risk model, for example the risk assessment 800 may include performing supervised learning using regression models such as multiple linear regression and tree-based regression, or using classification models such as decision tree, random forest. The model may be selected based on system considerations, e.g. depending on a desired model accuracy, computational speed, etc.

[00191] As mentioned, in various aspects, the risk profiler 500 (e.g., the risk assessment unit 530) may be configured to carry out the profiling in real-time, e.g. the risk profiler 500 may be configured to determine the risk score (and risk factors) during a driving session of the driver, illustratively while the driver is currently driving a vehicle. This configuration may allow providing real-time driving-related instructions (real-time driving advice), e.g. to the driver or to the vehicle (see also FIG.17A and FIG.17B).

[00192] In some aspects, in addition to determining the risk factors, the risk profiler 500 (e.g., the risk assessment unit 530) may be configured to determine, for each risk factor, a respective weight representative of the influence of the risk factor on the risk score. Illustratively, the risk profiler 500 may determine the relevance or importance of a certain risk factor in the calculation of the risk score, thus allowing a targeted identification of possible countermeasures. In this scenario, the risk profile of the driver may further include the weights of the risk factors, illustratively an indication of the relative contribution of each risk factor to the risk score.

[00193] As mentioned, the risk score and risk factors may be determined by evaluating the driving contextual data with respect to the (selected) events defining the driving-related risk. In this regard, the risk assessment 800 may include evaluating, for each event, whether the driving contextual information fulfill a respective criterion. In a preferred configuration, the risk assessment 800 may include comparing, for each event, the driving contextual data with a respective threshold for that event. As an example, considering the event “accident at night”, relevant thresholds may be in relation to the “age of the driver”, “eyesight of the driver”, “years of experience”, etc. The risk assessment 800 may compare the data representing the driver with the relevant thresholds to determine the risk score. Illustratively, a driver-related parameter being above or below a relevant threshold may indicate a higher or lower risk in relation to that event. As another example, the risk assessment 800 may include comparing, for each event, the driving contextual data with a respective binary condition for that event.

[00194] Considering the grouping, the criteria (e.g., the thresholds or binary conditions) for the events may vary among different driver groups. Thus, the risk assessment 800 may include evaluating, for each event, the driving contextual data with respect to a respective criterion for that event that is specific to the driver group to which the driver belongs. The risk assessment 800 may include comparing the driving contextual data with a respective threshold for an event that is specific to the driver group or, as another example, determining

whether an instance of the event occurred for the driver (as binary condition). For example, considering the event “speeding”, a first driver group may have first thresholds for the speed value, etc. a second driver group may have second (different) thresholds for the speed value, etc.

[00195] The risk assessment 800 may further include, in 830, providing the determined risk score and risk factors as output for the subsequent processing stage. For example, the risk assessment 800 may include providing a first output to the risk simulator and a second output to the operation adviser. As an exemplary configuration, the risk assessment 800 may include, in 840-1, determining the risk score, risk factors, and a respective importance of the risk factors (illustratively, a respective weight), and further, in 850-1, delivering the risk score, risk factors, and feature importance to interpretation and advisory unit (see also FIG.14A to FIG.14C). Further, the risk assessment 800 may include, in 840-2, determining the risk model used for determining the risk score and risk factors, and, in 850-2, delivering the risk model to pre-rostering and mapping unit (see also FIG.15A to FIG.15C).

[00196] **FIG.8B** shows the details of driving contextual data 860 that the risk assessment 800 may use for determining the risk score, risk factors, and respective relevance of the risk factors. The driving contextual data 860 used for the risk assessment 800 may correspond to the driving contextual data 400, e.g. the driving contextual data 860 may include driver data 864, route/environmental data 862, shift data 872, vehicle data 866, and telematics data 868. As a difference with respect to the driving contextual data 400, the risk assessment 800 may exclude the event data, which are rather used to define a “target to minimize”. Further, considering the scenario in which driver grouping is carried out, the driver data 864 may include (only) the dynamic data, e.g. only the extrinsic driver characteristics, thus excluding the intrinsic driver characteristics already used for assigning the driver to a driver group.

[00197] It is understood that the type of data described in relation to FIG.8B have been found to provide an accurate and comprehensive assessment of the risk score and risk factors associated with a driver, but in principle also additional, alternative, or less type of data may be considered for the risk profiling.

[00198] **FIG.8C** shows two graphs 870, 880 illustrating the response of a risk assessment unit, in form of a graphical representation of an exemplary calculation of a driver score (graph 870) and risk score (graph 880). It is understood that the aspects discussed in relation to FIG.8C are exemplary, to illustrate a possible convenient approach to the calculation of the risk score, but in principle also other types of calculations may be provided.

[00199] Exemplary methods to transform an “event occurrence” (a non-negative continuous value) into a risk score, e.g. with a numerical representation as a value between a low value (e.g., 0 to indicate the most dangerous driver) to a high value (e.g., 100 to indicate the safest driver), may include scalers such as standard scaler (assuming event occurrence follows normal distribution) and robust scaler. The mathematical transformation may define the relationship for driver evaluation as indicated in equation (2), and for minimizing risk in rostering as indicated in equation (3) (same as equation (1)),

$$\text{Driver score} = 100 \times a^x, \text{ with } 0 < a < 1 \quad (2)$$

$$\text{Risk score} = 100 \times (1 - a^x), \text{ with } 0 < a < 1 \quad (3)$$

[00200] As discussed above, the parameter “ a ” may represent the acceptable number of events occurring within the sampled time period for a driver scored 60 (assuming 2 in the figure, $a=\sqrt{0.6}$). For example, such information may be obtained as a user input, or from any other suitable source.

[00201] In relation to the modeling in the risk assessment unit, FIG.8D shows exemplary data 890 (in continuation to the example illustrated in FIG.7C). As shown in FIG.8D, the risk assessment 800 may include considering different drivers, e.g. identified via a unique driver ID 872, having different model groups 894 identified by characteristics 874, 876 (e.g., age, accident history, or any suitable driver characteristics) decided in DSU. The risk assessment 800 may further include determining for each driver a corresponding event occurrence 882 and the risk score 884, e.g. a risk score for the first driver AB, a further risk score for the second driver RA, etc. The risk assessment 800 may include determining the values for the event occurrence 882 and the risk score 884 over time, e.g. at different time points 878, to provide an up-to date evaluation.

[00202] As shown, the risk assessment 800 may also use information on the driver in relation to risk factors, such as route factors 886, shift factors 888, or any suitable other factor 892. The risk assessment 800 may also include a risk model 894 used (or to be used) for the driver, e.g. as determined in the driver stratification. For each model, the risk factors 886, 888, 892 may correspond to factors that the risk assessment 800 determines to be influential for the driving-related risk.

[00203] As mentioned above, it may happen that for a certain driver group insufficient data may be available. In this case, as shown in **FIG.9**, the risk profiler 500 (e.g., the risk assessment unit 530) may be configured to carry out an interpolation 900 (also referred to herein as interpolating risk) to ensure that a risk model may be defined for all drivers (e.g.,

including also candidate drivers in a hiring process). The interpolation 900 may thus provide a risk model for a driver group with insufficient sample size.

[00204] As shown, the interpolation 900 may include, in 910, determining a plurality of risk models for a plurality of (other) driver groups for which sufficient data are available (referred to herein as “sufficient driver groups”). With reference to the table representation in FIG.7C and FIG.8D, determining the plurality of risk models may include considering the related column indicating the model for a certain driver or driver group (e.g., model 1, model 2, etc.). In a simple scenario the interpolation may be based on two sufficient driver groups (and thus on two risk models) but it is understood that in principle also more complex interpolations considering more than two sufficient driver groups may be provided.

[00205] The sufficient driver groups may be “adjacent” to the insufficient driver group in terms of a driver characteristic. Illustratively, considering consecutive values (e.g., consecutive ranges) for the driver characteristic, the sufficient driver groups may be the preceding group and the subsequent group with respect to the insufficient driver group. In the exemplary case 950 in FIG.9, considering the age of the driver as characteristic, the sufficient driver groups may be for age from 40 to 50 (included), and from 60 (excluded) to 70, to allow an interpolation for the insufficient driver group from 50 (excluded) to 60 (included).

[00206] The interpolation 900 may further include, in 920, using the plurality of risk models for identifying the risk factors for the insufficient driver group. In some aspects, the interpolation 900 may further include using the plurality of risk models for identifying the respective weight (illustratively relevance) of each risk factor. For example, the interpolation may be a simple average among the values of the sufficient driver groups, or any other suitable type of interpolation (e.g., a weighted average).

[00207] The interpolation 900 may further include, in 930, generating a risk model (an interpolated risk model) for the insufficient driver group using the calculated risk factors for the insufficient driver group. The interpolation 900 may thus include aggregating the results of the interpolation in relation to the various risk factors to determine a risk model to be used for the risk assessment (e.g., the calculation of the risk score) for a driver belonging to the insufficient driver group.

[00208] **FIG.10** shows a risk simulator 1000 in a schematic representation according to various aspects. The risk simulator 1000 may be an exemplary configuration of the risk simulator 340 of FIG.3. It is understood that the aspects discussed in relation to the risk

simulator 1000 (and its components) may apply in general to the risk simulator 340 and to a configuration of the processor 204, 304, and vice versa.

[00209] In general, the risk simulator 1000 may be configured to generate a risk scenario for the driver based on the risk profile (risk score, risk factors, in some aspects weight of the risk factors) determined by the risk profiler. In various aspects, the risk simulator 1000 may generate the risk scenario according to two main sub-functions, namely interpretation 1010, and simulation 1020. Each function may be implemented by a corresponding unit or module of the risk simulator 1000, illustratively, an interpretation unit 1010 (IU), and simulation unit 1020 (SU). The interpretation unit 1010 may be configured to translate a numerical model into an intuitive description (e.g., a text description). The simulation unit 1020 may be configured to simulate risk scenarios for a driver, e.g. to assist in training and rostering or for any other suitable purpose discussed above. Considering drivers of a commercial fleet, the risk simulator 1000 may interact with the fleet operator to generate training advice, hiring advice, rostering advice, etc.

[00210] As discussed, aspects of the present disclosure may be based on the realization that in conventional scoring systems the drivers (and the operator) are not in the condition to understand what may be causing a low risk score, or what may be the relevant factors contributing to the risk score. According to various aspects, the risk simulator 1000 (e.g., the interpretation unit 1010) may be configured to generate a human-perceptible visual representation of the risk factors for a driver. Additionally or alternatively, the risk simulator 1000 may generate a human-perceptible visual representation of the risk scenario for the driver, e.g. including a risk rank of the driver within the respective driver group, and/or including a collective risk scenario. In a preferred configuration, the risk simulator 1000 (e.g., the interpretation unit 1010) may be configured to generate a textual representation of the risk factors and/or risk scenario, illustratively an explanatory text representing the relevant risk factors for the driver and/or representing the conditions that constitute the risk scenario. The risk simulator 1000 may further cause a transmission of the visual (e.g., textual) representation to a user of the system 200, 300, e.g. to the driver or to the operator, illustratively to a corresponding user device.

[00211] In general, the interpretation unit 1010 may receive the risk score and factors 1002 (from the risk profiler 330, 500), and may generate a risk scenario 1012 or a plurality of risk scenarios 1012 for the driver based on the risk profile. As mentioned, a risk scenario may represent driving-related conditions under which drivers are prone to higher risks. Considering

driver stratification, the interpretation unit 1010 may generate risk scenario(s) 1012 for each driver group, e.g. risk scenario(s) 1012 that are specific to the driver characteristics of a certain driver group.

[00212] The interpretation unit 1010 may provide more intuitive risk scenarios 1012 that are more easily understandable compared to a mere risk score and listing of risk factors. As an example, the interpretation unit 1010 may generate a textual representation of the risk scenario using an interpretation template 1004, which describes a risk scenario in plain words, and filling variable fields (blanks) of the template by mapping from the risk factors for the specific driver. For individual drivers, the risk scenario may further include a risk rank within his/her driver group to indicate the overall performance.

[00213] Turning to the simulation unit 1020, the simulation unit 1020 may be configured to generate driving-related instructions based on the risk scenario in case no predefined instructions are available for that scenario. Illustratively, the driving advice may be retrieved from an advice database 1030, but there may be risk scenarios for which driving advice has not been defined yet. In this cases, the risk simulator 1000 (e.g., the simulation unit 1020) may be configured to determine (e.g., simulate, generate) an advice 1022 for the risk scenario(s) 1012 defined by the interpretation unit. The simulation unit 1020 may further cause a storing of the simulated advice 1022 in the advice database 1030.

[00214] **FIG.11A** and **FIG.11B** illustrate an operation of the interpretation unit 1010. **FIG.11A** shows a schematic flow diagram of risk scenario generation 1100, e.g. the interpretation unit 1010 may be configured to carry out the (steps of) risk scenario generation 1100. **FIG.11B** shows an exemplary user interface for interpretation of a risk scenario. As mentioned, the purpose of the risk interpretation is to interpret influential factors in intuitive and understandable format. The interpretation may thus include translating the risk factors into (understandable) risk scenarios.

[00215] The risk scenario generation 1100 may include, in 1110, receiving the risk profile associated with a driver, or a plurality of risk profiles associated with the drivers of a driver group. The risk scenario generation 1100 may further include, in 1120, categorizing the risk factors, illustratively assigning the identified risk factors to a respective category. In principle, any suitable number of categories and any suitable types of categories may be used, depending on factors expected to be relevant for the driving-related risk. In the exemplary case in **FIG.11A** six different categories are considered, e.g. route factors, shift factors, driver factors, vehicle factors, telematics factors, and interactive factors. The categories may thus

include the types of driving contextual data described in relation to FIG.4 and FIG.8B, and a further category to consider the interaction among different types of factors. The categorizing 1120 may illustratively include a sorting of the risk factors by order of importance, e.g. order of (expected) influence or relevance for the driving-related risk. In this regard, FIG.11A shows an exemplary graph 1102 indicating for each risk factor a corresponding weight, e.g. a corresponding importance level. In the exemplary scenario in FIG.11A, the risk factors from the six categories in database may be sorted by their average feature importance.

[00216] The risk scenario generation 1100 may further include, in 1130, generating the human-perceptible representation of the risk scenario, e.g. a textual representation 1104 based on an interpretation template. The interpretation template may be a pre-set template to describe the risk scenario, and may be updated taking into account the weights of the risk factors, e.g. to show the risk factors in order of influence (e.g., with the most influential factor shown first).

[00217] The risk scenario generation 1100 may further include, in 1140, generating the risk scenario by using the risk factors and the risk score 1106. For example, the risk scenario generation 1100 may include retrieving the risk score from a risk score database. In some aspects, the risk scenario generation 1100 may include determining (e.g., calculating) the percentile of the risk score of the driver within the driver group to which the driver belongs (as risk rank).

[00218] The risk scenario may include, for example, a scenario description generated by mapping the factors into the interpretation template, and a risk rank (also referred to herein as risk rating or risk score rating) for the driver. In some aspects, a user may select which risk factors to include in the risk scenario (e.g., in the textual representation), for example the user may limit the risk scenario to the most relevant factor or factors (e.g., to the top three in order of importance, as an example), to avoid making the scenario description too long-winded. Based on each driver's risk score, a risk rank may also be added comparing with existing risk scores of other drivers in the same driver group. The scenario description and the risk rank may provide the risk scenario for a driver.

[00219] After the risk scenario has been generated, the risk scenario generation 1100 may include, in 1150, delivering the risk scenario as output, e.g. delivering the risk scenario to the operator advisor. For example, the risk scenario generation 1100 may include delivering the risk scenario to the advisory unit and/or monitoring unit of the operator advisor (see also FIG.17A and 17B).

[00220] FIG.11B shows an exemplary interface 1160a, 1160b for the interpretation unit for two different drivers (belonging to different driver groups). FIG.11B shows an example risk scenario generation and visualization in drivers' graphic user interface. As shown, for each driver the interpretation unit may start from the risk factors and generate a corresponding risk scenario, e.g. including a risk rank and a textual description of the risk scenario. For example, the first driver (A) may be in the group $\text{age} \leq 45$, without accident history and with chronic health condition, and the second driver (B) may be in the group $\text{age} > 65$, with accident history and with chronic health condition. FIG.11B shows different forms of textual representation, e.g. as a sequence of sentences (1160a) or as bullet points (1160b). By clicking a risk factor (underlined), a driver may be directed to a set of advice targeted at this risk factor and his/her driver group. Operators can also view this risk scenario when making advice in the operation advisor (e.g., in the advisory unit).

[00221] FIG.12 illustrates an operation of the simulation unit 1020. FIG.12 shows a schematic flow diagram of risk simulation 1200, e.g. the simulation unit 1020 may be configured to carry out the (steps of) risk simulation 1200. As mentioned, the purpose of the risk simulation 1200 is to simulate advice (for the driver or operator) based on the identified risk scenario, in case the advice database does not include (yet) an advice suitable for the risk scenario at hand. Illustratively, in case of a new risk scenario or drivers/operators requesting a new advice for an existing scenario, simulation unit 1020 may be triggered to simulate new advice and add to advice database 1030. The simulation unit 1020 may thus generate advice if existing advice is insufficient (e.g., when a new risk factor occurs, advice for a risk factor cannot be found in database or needs to be updated, or the like)

[00222] The risk simulation 1200 may thus include, in 1210, receiving the risk scenario(s) from the interpretation unit. For the generation of (new) advice, the risk simulation 1200 may include, in 1220, generating simulation parameters to reproduce the risk scenario in a simulation environment and, in 1230, extracting advice during a driving session in the simulation environment. Illustratively, the risk simulation 1200 may provide a simulation setup, e.g. for the operator, either considering a software-based simulation or a real-life simulation scenario, to allow mimicking the risk scenario. The risk simulation 1200 may further extract advice based on the driving session in the simulated environment, e.g. during training. The risk simulation 1200 may further include, in 1240, storing the generated advice in the advice database, e.g. appending/updating the advice to the advice database (DB). The

simulation may be an individual-level simulation, for a single driver, or a system level simulation, e.g. considering an entire commercial fleet or in general a plurality of drivers.

[00223] After setting up the targeted scenarios in driving simulators or real-world training field, the advice during the training session may then be extracted and added to the advice DB. The advice may be either directly updated by operators, interpolated from similar existing risk scenarios, or populated using domain-specific generative artificial intelligence (AI) tools. More accurately, it may also be obtained from the audio/video during training using more domain-specific large language systems.

[00224] **FIG.13** shows an operation advisor 1300 in a schematic representation according to various aspects. The risk simulator 1000 may be an exemplary configuration of the operation advisor 350 of FIG.3. It is understood that the aspects discussed in relation to the operation advisor 1300 (and its components) may apply in general to the operation advisor 350 and to a configuration of the processor 204, 304, and vice versa.

[00225] In general, the operation advisor 1300 may be configured to determine the targeted advice to be delivered as output of the risk assessment, e.g. the instructions to be delivered to a driver, an operator, a vehicle, etc. The operation advisor 1300 may thus interact with both fleet operators and drivers. In various aspects, the operation advisor 1300 may determine the targeted advice according to four sub-functions, namely advisory 1310, mapping 1320, rostering 1330, and monitoring 1340. Each function may be implemented by a corresponding unit or module of the operation advisor 1300, illustratively, an advisory unit 1310 (AU), a pre-rostering mapping unit 1320, a rostering unit 1330 (RU), and a monitoring unit 1340 (MU). The advisory unit 1310 may provide advice given each risk scenario and its risk level. The pre-rostering mapping unit 1320 may transform existing route/shift/vehicle/driver data to format of risk factors for risk score calculation. The rostering unit 1330 may generate an optimal driver roster. The monitoring unit 1340 computes and visualizes risk, trigger advice or other countermeasures.

[00226] The advisory unit 1310 may be configured to retrieve an advice from the advice database 1030 based on the risk scenario 1302 (delivered by the risk simulator). The advisory unit 1310 may be further configured to rank and edit the retrieved advice, e.g. to further tailor the advice to the specific risk scenario 1302. In some aspects, the advice database 1030 may be a dynamic knowledge database that stores risk scenarios and advice following one-to-many relationship for each driver group. As discussed in relation to FIG.2, the advice may include any operation suggestions or countermeasures such as driving advice 1304,

rostering advice 1306, training advice 1308, hiring advice 1312, or any other type of advice/instructions (e.g., also for the vehicle) based on the risk scenario 1302.

[00227] The driving advice 1304 may be more towards individual drivers (e.g., as driver instructions) and the roster advice 1306, training advice 1308, and hiring advice 1312 may more for operators to manage all drivers (e.g., as operator instructions). Depending on the risk rank in the risk scenario, the advisory unit may transmit different sets of driving advice to drivers. For example, low-risk drivers may only receive suggestions while exposed to the risk scenarios as judged in the monitoring unit 1340 whereas high-risk drivers may also be provided with suggestions before and/or after driving as an extra reminder. At the fleet level, if drivers are overall within an acceptable risk level, rostering advice 1306 may be sufficient. If the risk level of the fleet becomes high, the operators may identify the high-risk drivers and provide them with training advice 1308. If there is a need for new drivers because of new routes or personnel changes, hiring advice 1312 may also be provided to help operators hire the most suitable drivers given the task.

[00228] The pre-rostering mapping unit 1320 and rostering unit 1330 may be an exemplary realization in case of an application of the proposed strategy for rostering of a fleet of commercial vehicles.

[00229] The pre-rostering mapping unit 1320 may receive the risk profile(s) 1314, e.g. risk score and factors, and in some aspects the risk model and functions used for the assessment. The pre-rostering mapping unit 1320 may be configured to map existing route, vehicle and shift database according to the grouped features describing a driver group (e.g., the group features 522 delivered by the driver stratification unit 520). Static features such as driver demography and route geography information may be directly mapped. Dynamic features such as traffic condition and weather, may be updated using near-real-time data 1316 from external data sources. For dynamic features that cannot be estimated with external data sources such as fatigue level and telematics features, the pre-rostering mapping unit 1320 may estimate or predict such type of dynamic features based on historical data using methods such as time-series forecast. After mapping, the pre-rostering mapping unit 1320 may estimate a risk score of possible rostering configuration, e.g. a risk score of each driver-vehicle-route-shift combination. The estimation may be based, for example, on the risk models from the risk assessment unit 530 of the risk profiler 500. The estimation may become an additional input for the rostering 1330.

[00230] The rostering unit 1330 may be a rostering optimization unit configured to generate a roster to be used by an operator for assigning duties to the drivers of a commercial fleet. The rostering unit 1330 may consider both the event risk described herein and, in some aspects, other operational parameters and constraints 1318, e.g. describing existing rostering configurations. The rostering unit 1330 may thus be responsible for generating the roster advice 1306, which may include the driver-vehicle-route-shift combination that yields the lowest objective value globally. In some aspects, a user (e.g., the operator) may modify the definition of the objective functions by assigning different weights to targets such as the risk score, late arrival, or overtime hours, thus tailoring the rostering advice 1306 to the specific operator needs.

[00231] As an exemplary configuration, the rostering unit 1330 may be an optimization engine based on mathematical optimization methods such as mixed integer programming (MIP), heuristic algorithms such as Tabu search (e.g., according to the publications Fred Glover (1986). "Future Paths for Integer Programming and Links to Artificial Intelligence", Computers and Operations; Fred Glover (1989). "Tabu Search – Part 1". ORSA Journal on Computing. 1 (2): 190–206; 3; and Fred Glover (1990). "Tabu Search – Part 2". ORSA Journal on Computing. 2 (1)), or reinforcement learning depending on the problem scale and time requirement. As a special type of advice that may be evaluated, the optimal roster or user-modified roster may also be simulated in the simulation unit 1020 using fleet simulation software to assess the quality and gather feedback as new rostering advice.

[00232] The monitoring unit 1340 may be configured to calculate a real-time risk, e.g. based on real-time dynamic data 1334 and promptly notify drivers of the risk scenarios. In some aspects, the monitoring unit 1340 may receive the estimated risk 1332 for the roster defined by the rostering unit 1330 and may transmit a request for an alternative roster 1338 to the rostering unit 1330 if the monitoring unit 1340 determines a real-time risk that demands a roster change. Illustratively, the monitoring unit 1340 may transmit the request for an alternative roster 1338 prompting the rostering unit 1330 to generate a new roster, if the event risk for a driver is above a threshold. In some aspects, the monitoring unit 1340 may further consider abnormal rules 1336 for the real-time risk determination.

[00233] The monitoring unit 1340 may be further configured to notify a driver in real-time, illustratively to deliver driver instructions to the driver (and/or vehicle instructions to the vehicle) during a driving session. The monitoring unit 1340 may provide risk visualization 1342 using calculated real-time risk and/or the estimated risk 1332 and abnormal

alerts 1344 considering abnormal rules 1336 to allow monitoring and visualizing driver risk in real time, as will be discussed in further detail in relation to FIG.17A and FIG.17B.

[00234] **FIG.14A to FIG.14C** illustrate an exemplary configuration and operation of an advisory process 1400, according to various aspects. Illustratively, the advisory process 1400 may be an exemplary configuration of the advisory unit 1310, e.g. the advisory unit 1310 may be configured to carry out the (steps of) advisory process 1400. As mentioned, the purpose of the advisory process 1400 may be providing suggestions to drivers/operators based on the risk scenarios. The advisory process 1400 may include different levels of interventions based on the risk score. For example, the advisory process 1400 may provide recommendations from the advice database regarding subsequent training. As another example, the advisory process 1400 may provide targeted training, e.g. real-world training or facilitate scenario design in a driving simulator.

[00235] The advisory process 1400 may include, in 1410, receiving the risk score and risk scenario (from the risk profiler and risk simulator, respectively). The advisory process 1400 may further include, in 1420, determining whether the advice database contains sufficient advice for the risk scenario under consideration. If a suitable advice is found in the advice database, the advisory process 1400 may proceed directly to 1430 to extract targeted advice (from the advice database) according to the risk scenario at hand, e.g. according to the risk score and risk factors.

[00236] If the advice database does not include sufficient advice, the advisory process 1400 may proceed to 1440 and 1450 to prompt a generation of new advice. For example, the advisory process 1400 may include recording the risk scenario, 1440, and prompting the simulation unit 1020 to generate (simulate) new advice based on the risk scenario (e.g., using a suitable simulation environment, as discussed above). After the generation of the new advice, the advisory process 1400 may proceed to 1430 to extract targeted advice based on the output of the simulation unit 1020.

[00237] The advisory process 1400 may further include, in 1460, delivering the advice as output. For example, the advisory process 1400 may include delivering the advice to the rostering unit 1330 to prompt the generation of a roster. As another example the advisory process 1400 may include delivering the advice to the monitoring unit to prompt the generation of real-time driving-related instructions. In general, the advisory process 1400 may include delivering the advice to a user, e.g. a driver, or an operator.

[00238] FIG.14B shows an exemplary advice generation 1470. In particular, FIG.14B shows an exemplary configuration 1472 of the advice database, illustrating a mapping between exemplary risk factors 1474 and a corresponding countermeasure 1476. FIG.14B further shows exemplary observations 1478 including a mapping between driver groups 1482 and corresponding risk factors 1484. In general, the advice generation 1470 may use, as inputs, an advice set (from the database), observations, risk score and risk factors, and may deliver as output mapped condition and action to a particular driver group. The advice generation 1470 may include building a connection to the advice database (e.g., to find advice prepared by experts/operators or suggested by drivers), gather observations to detect and map the actions to driver group, and select action based on the driver group, and observations.

[00239] FIG.14C shows an exemplary interface 1490 for the advisory unit. In the exemplary case in FIG.14C, starting from a risk scenario 1488 delivered by the risk simulator, the advisory unit may provide driver instructions 1492 and operator instructions 1494 including targeted countermeasures based on the risk scenario 1488.

[00240] FIG.15A to FIG.15C illustrate an exemplary configuration and operation of pre-rostering mapping 1500, according to various aspects. Illustratively, the pre-rostering mapping 1500 may be an exemplary configuration of the pre-rostering mapping unit 1320, e.g. the pre-rostering mapping unit 1320 may be configured to carry out the (steps of) pre-rostering mapping 1500. As mentioned, the purpose of the pre-rostering mapping 1500 may be calculating a risk score for each route-shift-vehicle-driver combination, e.g. using the risk models identified by the risk assessment unit 530.

[00241] The pre-rostering mapping 1500 may include, in 1510, receiving the risk factors, e.g. from the risk assessment unit. The pre-rostering mapping 1500 may further include, in 1520, encoding possible roster configurations (e.g., route/shift/vehicle combinations) according to the corresponding features in the risk scenarios (the features in the risk assessment unit). Illustratively, the pre-rostering mapping 1500 may include, in 1530, considering the risk factors and functions for each driver group (considering the drivers to be included in the roster). The pre-rostering mapping 1500 may further include, in 1540, determining whether the factors are static. For static features, the pre-rostering mapping 1500 may proceed directly to 1550 and simply map to the risk function, e.g. according to the feature definition in risk assessment unit, and then to calculating the risk score, 1560, for the roster. For dynamic features, the pre-rostering mapping 1500 may proceed to 1570 and, if external data source is useful (e.g. weather, traffic volume) proceed to 1580 and map the risk score with

information from external data source. If the external data source is not useful (e.g., for fatigue level, telematics response), proceed to 1590 and predict the risk score with historical data using methods such as time-series forecast.

[00242] FIG.15B and FIG.15C show two exemplary operations 1502a, 1502b of the pre-mapping rostering. Illustratively, FIG.15B and FIG.15C show the generating of risk scores 1512a, 1512b for different drivers/rosters starting from route data 1504, vehicle data 1506, and shift data 1508. It may be assumed that the various factors 1504, 1506, 1508 have been one-hot encoded. The first column under route data 1504, vehicle data 1506 and shift data 1508 may refer to the ID. The other columns are the factors encoded according to the feature encoding in the risk profiler. In this example, the risk function for driver A's group contains five risk factors. Assuming they are of equal coefficients, the best roster for driver A based on event risk only is Route 97 under Shift 2 driving Vehicle 1 or 2.

[00243] FIG.16A to FIG.16C illustrate an exemplary configuration of a rostering operation 1600, according to various aspects. Illustratively, the rostering operation 1600 may be an exemplary configuration of the rostering unit 1330, e.g. the rostering unit 1330 may be configured to carry out the (steps of) rostering operation 1600. As mentioned, the purpose of the rostering operation 1600 may be to generate an optimal driver roster that considers both common operational parameters and risk factors to minimize operational costs (incl. safety risks). The rostering operation 1600 may be referred to herein also simply as rostering.

[00244] As discussed in relation to FIG.2, the processor 204, 304 may receive driving contextual data associated with a plurality of drivers and determine, for each driver a corresponding risk score, risk factors, and risk scenario(s). In some aspects, the processor 204, 304 (e.g., as part of the operation of the rostering unit 1330) may further determine (e.g., simulate) a plurality of roster configurations, wherein each roster configuration includes an allocation of each driver of the plurality of drivers to respective roster features, such as vehicle, shift, and route. Illustratively, the plurality of drivers may belong to a fleet of commercial vehicles, and the processor 204, 304 may simulate a plurality of driver-vehicle-shift-route combinations. The processor 204, 304 may further select the roster configuration among the plurality of (simulated) roster configurations based on one or more optimization parameters. Illustratively, the processor 204, 304 may select the roster configuration that optimizes one or more key performance indicators, for example the roster configuration that minimizes an overall driving-related risk, and/or the roster configuration that minimizes operational costs, or any suitable optimization parameter or combination thereof. The processor 204, 304 may

further transmit the roster configuration to the fleet operator, e.g. may cause the fleet operator to control a rostering of the commercial fleet based on the selected roster configuration.

[00245] In this regard, the rostering 1600 may include, in 1610, receiving input data for the rostering. For example, the rostering 1600 may include receiving a risk score 1612 for each roster configuration, e.g. a risk score for each driver-route-vehicle-shift combination. The rostering 1600 may further include receiving further operational parameters 1614 that may be considered for determining the optimal roster configuration. The operational parameters 1614 may include any suitable roster-related parameters or rules, such as working hours, driver availability, customer preferences, and the like.

[00246] The rostering 1600 may further include, in 1620, evaluating each roster configuration, e.g. calculating objectives for each possible roster, for example as a weighted combination between risk score 1612 and other operational cost 1614. The rostering 1600 may further include, in 1630, running an optimization engine to find a roster configuration based on one or more optimization parameters. The optimization engine may minimize a global objective value. The optimization engine may be realized in any suitable manner. For example, the optimization engine may include mathematical optimization methods such as mixed integer programming (MIP), heuristic algorithms such as Tabu search, or reinforcement learning depending on the problem scale and time requirement.

[00247] The rostering 1600 may further include, in 1640, selecting the roster configuration that provides optimized parameters, e.g. the roster configuration that minimizes overall risk and operational costs. The rostering 1600 may thus include delivering, as output, the optimal driver roster and estimated risk calculated from risk function of the driver group.

[00248] FIG.16B and FIG.16C show an exemplary interface for the rostering unit and exemplary optimization parameters. For example, the optimization parameters 1616 may include various KPI such as risk, overtime hours, workload, shift hours, and the like. A user may select the KPI to be considered for the rostering and, in some aspects, may assign a weight to each KPI to determine the relevance of that KPI in the optimization. The rostering 1600 may further provide an overview 1618 of the roster configuration, indicating for each driver-route-vehicle-shift combination a corresponding risk. FIG.16C shows an exemplary evaluation 1622 of different roster configurations, in this exemplary case, assuming that the scores have been adjusted with operational factors, Roster 2 may be the optimal roster out of the three, followed by Roster 3.

[00249] **FIG.17A** and **FIG.17B** illustrate an exemplary configuration of a monitoring operation 1700, according to various aspects. Illustratively, the monitoring operation 1700 may be an exemplary configuration of the monitoring unit 1340, e.g. the monitoring unit 1340 may be configured to carry out the (steps of) monitoring operation 1700. As mentioned, the purpose of the monitoring operation 1700 may be to calculate real-time risk, visualize estimated and real-time risk (e.g., in three views such as line chart, heatmap and dash cam overlay), inform operator of abnormal situation (e.g., actual risk higher than estimated risk for certain time period) and targeted advice, and allow ad-hoc roster to be triggered (e.g., in case backup drivers or ad-hoc schedule change are needed, and the like).

[00250] As discussed in relation to FIG.2, the processor 204, 304 may be configured to carry out the risk assessment in real-time, e.g. during a driving session of a driver (illustratively, a driving session may be a time period during which the driver is driving a vehicle). In various aspects, the processor 204, 304 (e.g., as part of the operation of the monitoring unit 1340) may determine the determine the risk score of a driver during a driving session as a real-time risk score. The processor 204, 304 may further compare the real-time risk score with an estimated risk score, illustratively predicted considering the driving conditions, such as route, type of vehicle, time of day, etc. The processor 204, 304 may thus carry out a performance monitoring to evaluate the current driving performance of the driver and verify whether abnormal deviations from the expected risk occur.

[00251] The processor 204, 304 may further determine real-time driving-related instructions based on the result of the comparison. Illustratively, the processor 204, 304 may generate real-time countermeasures to bring the real-time risk score in line with the estimated risk score (illustratively, an expected value for the risk score). The real-time driving-related instructions may be transmitted to the user of the system 200, 300 (illustratively, to a user device) to prompt real-time countermeasures. For example, the real-time driving-related instructions may include vehicle instructions transmitted to the vehicle being driven in the driving session and cause the vehicle to autonomously adapt (e.g., cause a derating of) one or more driving parameters or vehicle parameters, such as speed, light, etc. to reduce the real-time risk. As another example, the real-time driving-related instructions may include operator instructions transmitted to the operator to prompt countermeasures at the operator-side, such as an updating of the roster, sending backup drivers, etc. As a further example, the real-time driving-related instructions may include driver instructions prompting an action from the driver. For example, the driver instructions may cause a visual representation of the real-time

risk score to be displayed to the driver during the driving session, and further to cause a display of real-time advice to the driver (see FIG.17B).

[00252] Turning to FIG.17A the monitoring operation 1700 may include using the risk functions associated with the driver group of the driver (1705) and static/dynamic features to determine (and plot) and estimated risk (ER), illustratively a predicted risk score for the route. The monitoring operation 1700 may further include using real-time dynamic data 1715 to determine a real-time risk score, illustratively an actual risk (AR) in real-time (1720) and update the risk map with the real-time risk (1725).

[00253] As a first aspect, the monitoring operation 1700 may include, in 1740, comparing the actual risk with the estimated risk, and determine whether the difference is greater than a threshold. The real-time risk may be compared with the estimated risk, and the estimated risk may be computed based on the optimal roster and predicted dynamic features. In case of the difference greater than threshold or an upcoming risk scenario, advice may be sent to driver and related data such as contextual data and dashcam footage may be archived for evaluation (1745).

[00254] A trigger may be cause by the persistence of the abnormal situation of elevated actual risk for a certain period of time (Δt), 1750. If the real-time risk score remains different from the estimated risk-score by a difference greater than the threshold for a duration longer than a threshold duration, the generation of the real-time driving related instructions may be triggered, 1755. For example, if an abnormal rule is set as such condition persisting beyond a specified duration, abnormal alerts may be automatically triggered and sent to operators.

[00255] As an alternative way of triggering countermeasures, the operators may choose to initiate an ad-hoc roster change, 1760, 1765 in the event of specific emergency situations such as when a driver's physiological data indicates he/she is unfit to operate. In that case, rostering unit will suggest an alternative roster given the condition at that time, 1770.

[00256] As a second aspect, the monitoring operation 1700 may include causing (e.g., triggering) a visualization of the actual risk. For example (see also FIG.17B), the monitoring operation 1700 may cause the visualization (1735) as an overlay of real-time risk for different paths (e.g., different lanes) on a live dash cam footage (1730). It is understood that other types of visualization may be provided, e.g. as one-dimensional, two-dimensional, or three-dimensional visualizations. Considering a driver, the monitoring operation 1700 may

include causing a display of the real-time risk at a user device of the driver (e.g., a smartphone, a on board computer system of the driven vehicle, and the like).

[00257] FIG.17B shows an exemplary interface 1775 for the monitoring unit 1340, in which the interface 1775 provides real-time information on the risk score of a plurality of drivers for the operator. FIG.17B further shows possible visualization of real-time risk score and advice, e.g. for a driver. For example, the visualization 1780 may be in one-dimension, e.g. along time such as a line chart. As another example, the visualization 1785 may be in two-dimensions, e.g. along the route for example as a heatmap with a color gradient from a color indicating a low risk to another color indicating a high risk. As a further example, the visualization 1790 may be in three-dimension, e.g. on the drivers' point of view (POV) as an augmented reality overlay.

[00258] The three types of risk map 1780, 1785, 1790 may be provided on a web interface designed for operators and mobile interface mainly designed for drivers. For operators, they can view the estimated risk and real-time risk of all active drivers from the roster overview table 1775. After zooming in to a specific driver (driver A in this example), operators can see the real-time and estimated risk score plotted along the estimated time span of the trip in view 1780.

[00259] For drivers, they may slide a toggle to switch to show risk as an overview or from drivers' point of view. The overview is shown along the route with the event risk visualized by different colors on a heatmap 1785. Given a global satellite navigation system that is capable of supporting high accuracy and achieve lane-level positioning, such heatmap may be visualized in a higher resolution with different lanes showing different colors when the risk of each lane is different. A more intuitive visualization of such lane-level risk may be from the drivers' point of view. Utilizing the dashcam footage and computer vision technology, each lane may be segmented by recognizing road markings. The heatmap may then be imposed as an augmented reality overlay on the footage. Similarly, other objects such as traffic signs and signals may also be utilized to achieve this function. The three-dimensional visualization 1790 shows an example where the current risk scenario is the rightmost lane and the approaching expressway exit on the leftmost lane. As a result, the corresponding areas may be highlighted in different colors to indicate a potential increase in risk when driving at those locations. For example, in the depicted scenario the risk score may be visualized as a color gradient superimposed to the route travelled by the driver. As an example the lane at the right-hand side may present the highest risk and may thus be shown with an overlay in a first color (e.g., at one

edge of a color spectrum, for example “red”). The central lane may present the lowest risk and may be shown with an overlay in a second color (e.g., at the opposite edge of a color spectrum, for example “green”). The lane at the left-hand side may present an intermediate risk that varies along the lane and may thus be shown with an overlay showing a color gradient (e.g., with a color varying gradually from green to red along the lane depending on the risk at a specific location). When needed, operators can also access view 1785, 1790, especially the three-dimensional view 1790 to provide real-time guidance or archive the footage for driver training.

[00260] **FIG.18** shows a risk assessment system 1800 in a schematic representation. The risk assessment system 1800 may be an exemplary configuration of the computer system 200, e.g. of the risk assessment system 300. FIG.18 provides a combined view with a detailed representation of the various components, inputs, outputs, and interrelationships. The various functionalities, data, configurations, etc. have been discussed in detail in relation to FIG.5 to FIG.17B, so that a repetition of the previously discussed aspects will be dispensed with. In brief, the risk assessment system 1800 may include a risk profiler 1810, e.g. including an event definition unit 1812, driver stratification unit 1814, and risk assessment unit 1816. The risk assessment system 1800 may further include a risk simulator 1820, e.g. including an interpretation unit 1822 and a simulation unit 1824. The risk assessment system 1800 may further include an operation advisor 1830, e.g. including a pre-rostering mapping unit 1832, a rostering unit 1834, and a monitoring unit 1836.

[00261] In conclusion, the approach proposed herein includes a modeling of driver risk using data stratified by driver characteristics. In stratifying drivers by their risk patterns, each driver may be evaluated under their homogeneous group. Within each group/model, more suitable definitions or thresholds are enabled for the same features. As a result, influential risk factors specific to each driver group may be captured, yielding a fairer risk score and driver performance evaluation.

[00262] As a further aspect, the proposed strategy may include identifying and interpreting risk scenarios in a way that are easily comprehensible for drivers and operators and providing targeted advice. The risk scenarios allow drivers to be aware and alerted of the conditions under which they are prone to higher risks. Coupled with driving advice generated from advice DB, drivers can be more educated and proactive in improving their performance. In case of drivers with high risk scores, operators may either choose to have more targeted training setup or hire more suitable drivers.

[00263] As a further aspect, the proposed strategy may include using risk scores from driver assessment as additional input for optimizing driver rosters. By mapping existing routes, shifts and vehicles to features in profiling, the risk score of each driver and route-shift-vehicle combination may be calculated and represented in rostering. Hence, the optimized roster is expected to be safer compared to conventional operation-based roster. Moreover, it can also recommend drivers for newly created or spontaneous schedules, where limited or no reference can be drawn due to data scarcity.

[00264] As a further aspect, the proposed strategy may include building and updating a dynamic advice database mapped from risk scenarios. The advice database stores and provides targeted advice to drivers or operators upon request or in real-time when a risk scenario occurs. This database may be initially established by input from operators, generative AI tools, or more domain-specific language systems and subsequently updated by extracting key information during training or simulation from audio or video data.

[00265] Finally, the proposed strategy may include visualizing estimated and real-time risks in three dimensions. The visualization of real-time risk in a 1D line chart, 2D map and 3D drivers' point of view helps both drivers and operators to more intuitively perceive the risk scenarios and risk levels.

[00266] Aspects of the present disclosure may thus be related to a system that identifies driver risk scenarios to reduce incidents such as accident, vehicle breakdown or high fuel consumption. The present disclosure may thus be related to a driver assignment, rostering or scheduling method based on the risk of accident, vehicle breakdown, or high fuel consumption using mathematical optimization that may be used for fleet management system of commercial vehicles such as trucks or buses.

[00267] According to various aspects, a system may be provided. The system may include a driver risk profiler configured to extract risk factors related to drivers from driving related information and calculates risk scores of the drivers using the extracted risk factors. The system may further include a risk simulator configured to generate risk scenarios for driver training based on the extracted risk factors and the calculated risk scores. The system may further include an operation advisor configured to issue advice related to the drivers using the extracted risk factors, the calculated risk scores, and the generated risk scenarios.

[00268] According to various aspects, the driver risk profiler may carry out a driver risk profiling method that builds risk assessment models for each driver group with similar risk

pattern using machine learning algorithms, and extracts significant risk factors from related information such as driver, vehicle, route, shift, and telematics data.

[00269] According to various aspects, the risk simulator may generate risk scenarios using relative rank of risk scores within the driver group and intuitive description mapped from most influential risk factors. The risk simulator may further generate new advice under simulated risk scenario from training audio/video using generative AI or other domain-specific large language systems.

[00270] According to various aspects, the operation advisor may issue driving, rostering, training, and hiring advice based on risk scenarios. The operation advisor may further calculate real-time risk scores using real-time data and compare with estimated risk for performance monitoring. The operation advisor may further provide risk visualization from three dimensions: against time, against route on 2D map and overlay on 3D dashcam footage using augmented reality technology.

[00271] The term “data” as used herein may be understood to include information in any suitable analog or digital form, e.g., provided as a file, a portion of a file, a set of files, and the like. Further, the term “data” may describe a reference to information, e.g., in form of a pointer.

[00272] As used herein, “memory” is understood as a computer-readable medium (e.g., a non-transitory computer-readable medium) in which data or information can be stored for retrieval. References to “memory” included herein may thus be understood as referring to volatile or non-volatile memory, including random access memory (RAM), read-only memory (ROM), flash memory, solid-state storage, magnetic tape, hard disk drive, optical drive, and the like, or suitable combinations of different memory types. The term “software” refers to any type of executable instruction, including firmware.

[00273] The term “processor” or “processing circuit” as used herein may be understood as any kind of technological entity that allows handling of data. The data may be handled according to one or more specific functions that the processor or processing circuit may execute. Further, a processor or processing circuit as used herein may be understood as any kind of circuit, e.g., any kind of analog or digital circuit. A processor or processing circuit may thus be or include an analog circuit, digital circuit, mixed-signal circuit, logic circuit (e.g., a hard-wired logic circuit or a programmable logic circuit), microprocessor, Central Processing Unit (CPU), Graphics Processing Unit (GPU), Digital Signal Processor (DSP), Field Programmable Gate Array (FPGA), integrated circuit, Application Specific Integrated Circuit

(ASIC), etc., or any combination thereof. It is understood that any two (or more) of the processors or processing circuits detailed herein may be realized as a single entity with equivalent functionality or the like, and conversely that any single processor or processing circuit detailed herein may be realized as two (or more) separate entities with equivalent functionality or the like.

[00274] As used herein, the singular forms “a”, “an” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms “comprises” and/or “comprising,” when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. Unless specifically stated otherwise, the term “some” refers to one or more. Combinations such as “at least one of A, B, or C,” “one or more of A, B, or C,” “at least one of A, B, and C,” “one or more of A, B, and C,” and “A, B, C, or any combination thereof” include any combination of A, B, and/or C, and may include multiples of A, multiples of B, or multiples of C. Specifically, combinations such as “at least one of A, B, or C,” “one or more of A, B, or C,” “at least one of A, B, and C,” “one or more of A, B, and C,” and “A, B, C, or any combination thereof” may be A only, B only, C only, A and B, A and C, B and C, or A and B and C, where any such combinations may contain one or more member or members of A, B, or C.

[00275] All structural and functional equivalents to the elements of the various aspects described throughout this disclosure that are known or later come to be known to those of ordinary skill in the art are expressly incorporated herein by reference and are intended to be encompassed by the claims. Moreover, nothing disclosed herein is intended to be dedicated to the public regardless of whether such disclosure is explicitly recited in the claims. The words “module,” “mechanism,” “element,” “device,” and the like may not be a substitute for the word “means.” As such, no claim element is to be construed as a means plus function unless the element is expressly recited using the phrase “means for.”

[00276] It should be understood that the terms “on”, “over”, “top”, “bottom”, “down”, “side”, “back”, “left”, “right”, “front”, “lateral”, “side”, “up”, “down” etc., when used in the present description are used for convenience and to aid understanding of relative positions or directions, and not intended to limit the orientation of any device, structure or any part of any device or structure. In addition, the singular terms “a”, “an”, and “the” include

plural references unless context clearly indicates otherwise. Similarly, the word “or” is intended to include “and” unless the context clearly indicates otherwise.

[00277] The term “coupled” (or “connected”) herein may be understood as electrically coupled or as mechanically coupled, for example attached or fixed, or just in contact without any fixation, and it will be understood that both direct coupling or indirect coupling (in other words: coupling without direct contact) may be provided.

[00278] While embodiments of the invention have been particularly shown and described with reference to specific embodiments, it should be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the invention as defined by the appended claims. The scope of the invention is thus indicated by the appended claims and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced. It will be appreciated that common numerals, used in the relevant drawings, refer to components that serve a similar or the same purpose.

CLAIMS

1. A computer system for generating driving-related instructions, the computer system comprising:
 - a processor; and
 - a memory configured to store instructions, wherein the instructions, when executed by the processor, cause the processor to:
 - obtain driving contextual data associated with a driver,
 - wherein the driving contextual data are representative of driver-related parameters influencing a driving performance of the driver;
 - determine a personalized risk profile associated with the driver based on the driving contextual data,
 - wherein the personalized risk profile comprises a risk score associated with a driving-related risk for the driver and risk factors influencing the risk score;
 - determine a risk scenario associated with the driver based on the personalized risk profile,
 - wherein the risk scenario is representative of driving-related conditions causing an increased driving-related risk for the driver; and
 - determine the driving-related instructions associated with the driver based on the personalized risk profile and on the risk scenario.
2. The computer system according to claim 1,
 - wherein the driving-related risk comprises one or more events; and
 - wherein the instructions are further configured to cause the processor to determine the personalized risk profile associated with the driver by evaluating the driver-related parameters with respect to a corresponding criterion for each of the one or more events
3. The computer system according to claim 1 or 2,
 - wherein the instructions are further configured to cause the processor to cause a transmission of the generated driving-related instructions to a user device communicatively coupled with the computer system.
4. The computer system according to any one of claims 1 to 3,

wherein the driving-related instructions comprise vehicle instructions addressed to a vehicle driven by the driver and configured to prompt the vehicle to implement an autonomous functionality to reduce the driving-related risk associated with the driver.

5. The computer system according to any one of claims 1 to 4,
wherein the driver is a driver of a commercial vehicle part of a fleet of commercial vehicles;
wherein the driving-related instructions comprise operator instructions addressed to an operator of the commercial fleet, and
wherein the operator instructions are representative of a rostering for the commercial fleet comprising the driver.
6. The computer system according to any one of claims 1 to 5,
wherein the driving-related instructions comprise or are representative of one or more simulation parameters to define a simulation environment for training the driver.
7. The computer system according to any one of claims 1 to 6,
wherein the instructions are further configured to cause the processor to:
assign the driver to a corresponding driver group based on one or more driver characteristics represented by the driving contextual data associated with the driver.
8. The computer system according to claim 7,
wherein the instructions are further configured to cause the processor to determine the personalized risk profile for the driver according to the driver group to which the driver is assigned.
9. The computer system according to claim 7 or 8,
wherein the driving-related risk comprises one or more events; and
wherein the instructions are further configured to cause the processor to determine the personalized risk profile associated with the driver by evaluating the driver-related parameters with respect to a corresponding criterion for each of the one or more events, and

wherein the criteria for the events are specific to the driver group to which the driver is assigned.

10. The computer system according to any one of claims 1 to 9,
 - wherein the instructions are further configured to cause the processor to:
 - determine the risk score during a driving session of the driver as a real-time risk score;
 - compare the real-time risk score with a predicted value of the risk score for the driving session;
 - determine real-time driving-related instructions based on a result of the comparison;
 - and cause a transmission of the real-time driving-related instructions to a user-device of the driver during the driving session.
11. A method for generating driving-related instructions, the method comprising:
 - obtaining driving contextual data associated with a driver,
 - wherein the driving contextual data are representative of driver-related parameters influencing a driving performance of the driver;
 - determining a personalized risk profile associated with the driver based on the driving contextual data,
 - wherein the personalized risk profile comprises a risk score associated with a driving-related risk for the driver and risk factors influencing the risk score;
 - determining a risk scenario associated with the driver based on the personalized risk profile,
 - wherein the risk scenario is representative of driving-related conditions causing an increased driving-related risk for the driver; and
 - determining the driving-related instructions associated with the driver based on the personalized risk profile and on the risk scenario.
12. The method according to claim 11,
 - wherein the driving-related risk comprises one or more events; and
 - wherein the method further comprises determining the personalized risk profile associated with the driver by evaluating the driver-related parameters with respect to a corresponding criterion for each of the one or more events

13. The method according to claim 11 or 12,
further comprising: transmitting the generated driving-related instructions to a user device communicatively coupled with the computer system.
14. The method according to any one of claims 11 to 13,
wherein the driving-related instructions comprise vehicle instructions addressed to a vehicle driven by the driver and configured to prompt the vehicle to implement an autonomous functionality to reduce the driving-related risk associated with the driver.
15. The method according to any one of claims 11 to 14,
wherein the driver is a driver of a commercial vehicle part of a fleet of commercial vehicles,
wherein the driving-related instructions comprise operator instructions addressed to an operator of the commercial fleet, and
wherein the operator instructions are representative of a rostering for the commercial fleet comprising the driver.
16. The method according to any one of claims 11 to 15, further comprising:
using the driving-related instructions to define one or more simulation parameters of a simulation environment for training the driver.
17. The method according to any one of claims 11 to 16, further comprising:
assigning the driver to a corresponding driver group based on one or more driver characteristics represented by the driving contextual data associated with the driver.
18. The method according to claim 17, further comprising:
determining the personalized risk profile for the driver according to the driver group to which the driver is assigned.
19. The method according to claim 17 or 18,
wherein the driving-related risk comprises one or more events; and

wherein the method further comprises determining the personalized risk profile associated with the driver by evaluating the driver-related parameters with respect to a corresponding criterion for each of the one or more events, and

wherein the criteria for the events are specific to the driver group to which the driver is assigned.

20. The method according to any one of claims 11 to 19, further comprising:

determining the risk score during a driving session of the driver as a real-time risk score;

comparing the real-time risk score with a predicted value of the risk score for the driving session;

determining real-time driving-related instructions based on a result of the comparison;

and transmitting the real-time driving-related instructions to a user device of the driver during the driving session.