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(54) METHODS AND SYSTEMS FOR DECISION SUPPORT

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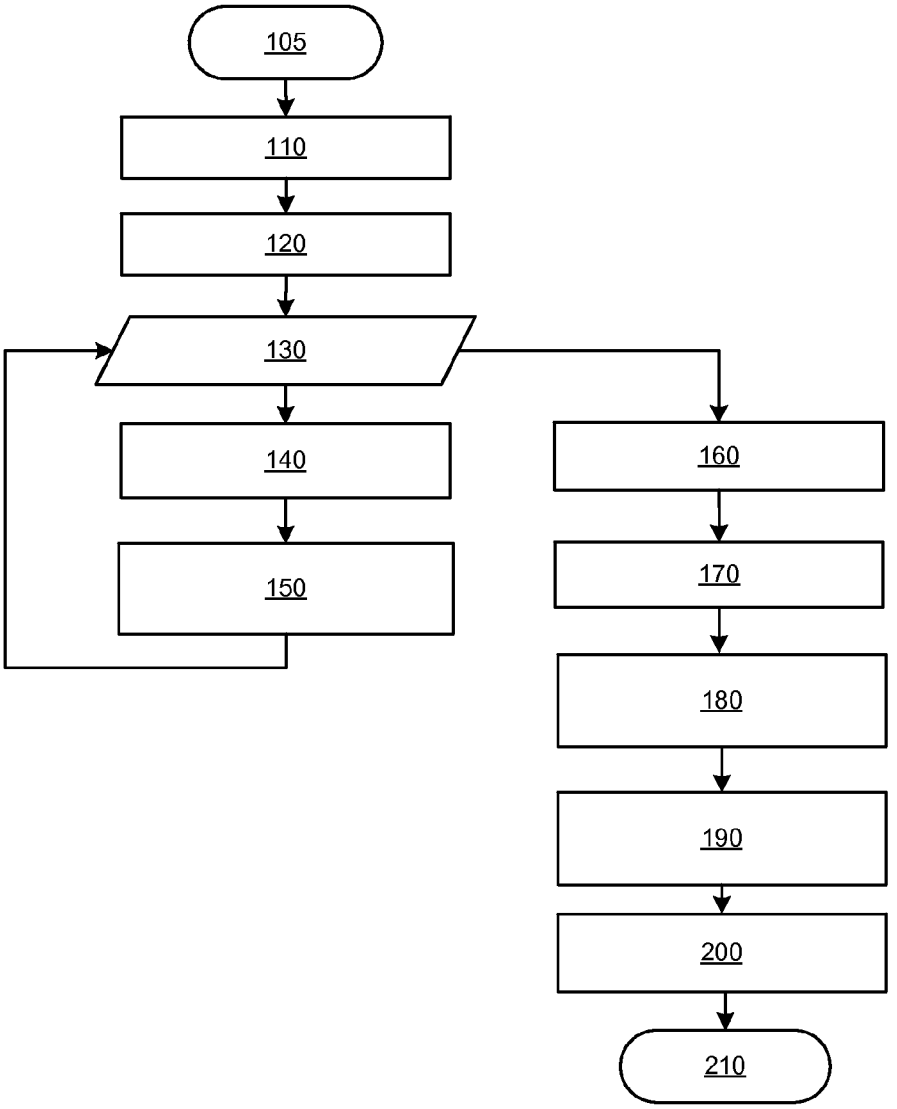
(57) **ABSTRACT**

Methods and systems are provided for providing decision support. In one embodiment, a method includes: receiving a recommendation associated with a vehicle; receiving contextual data associated with the vehicle; determining a risk factor based on the recommendation and the contextual data; and generating notification data based on the risk factor to notify a user of the vehicle of the risk factor associated with the recommendation.



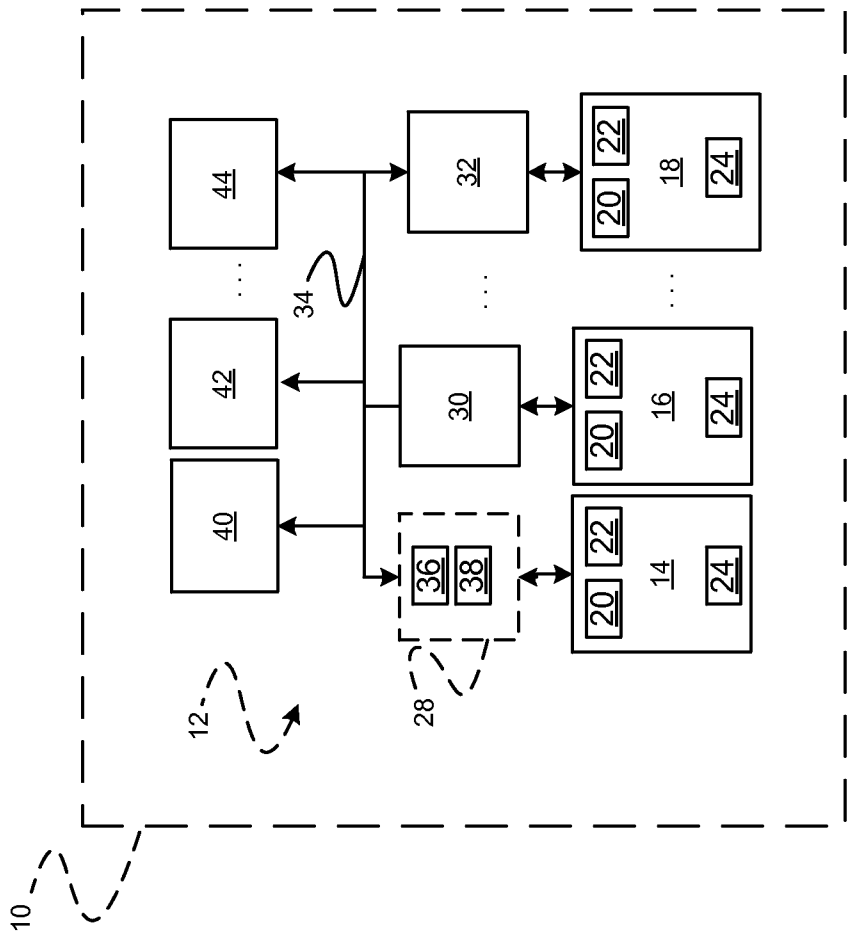


FIG. 1

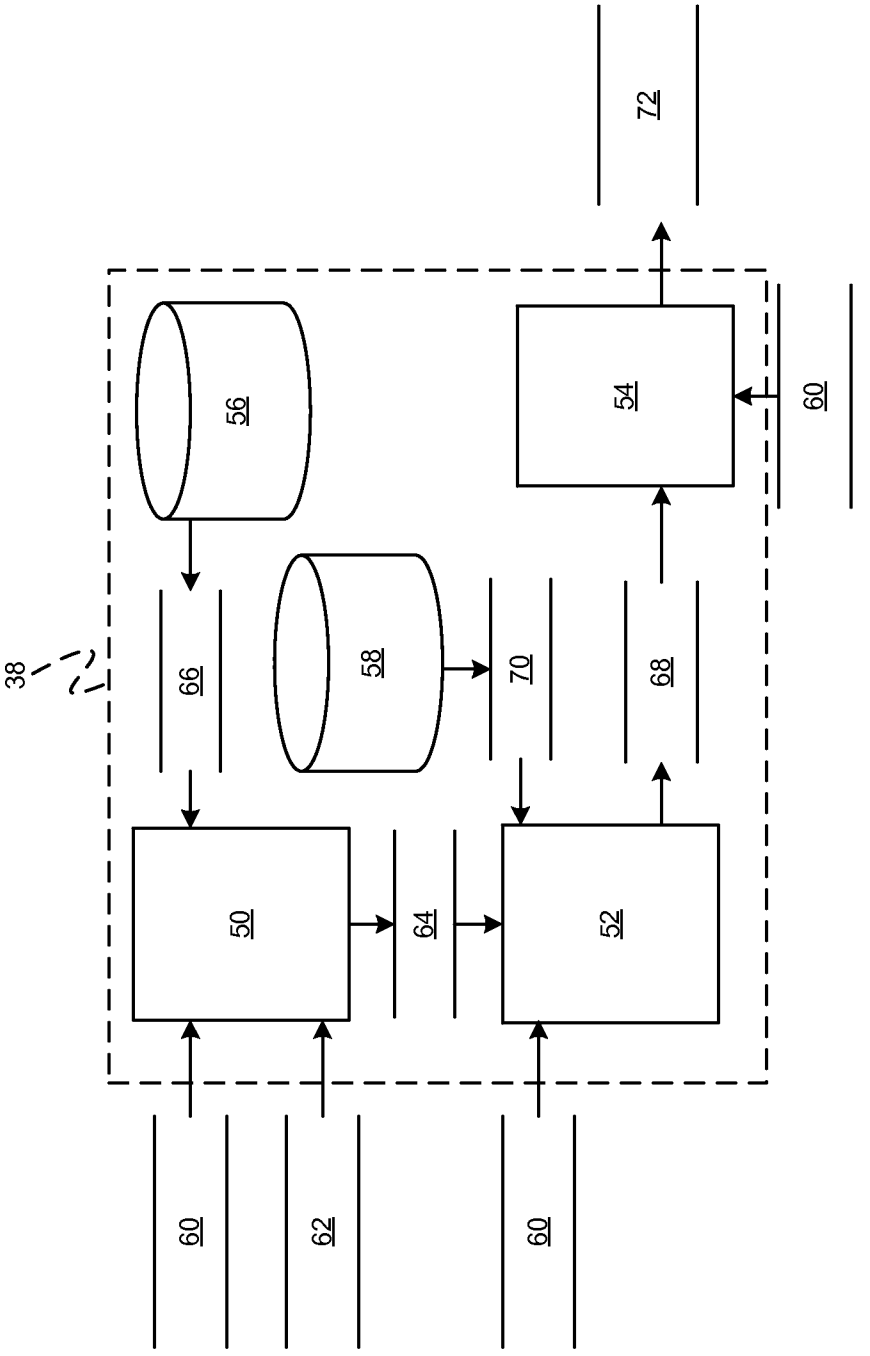


FIG. 2

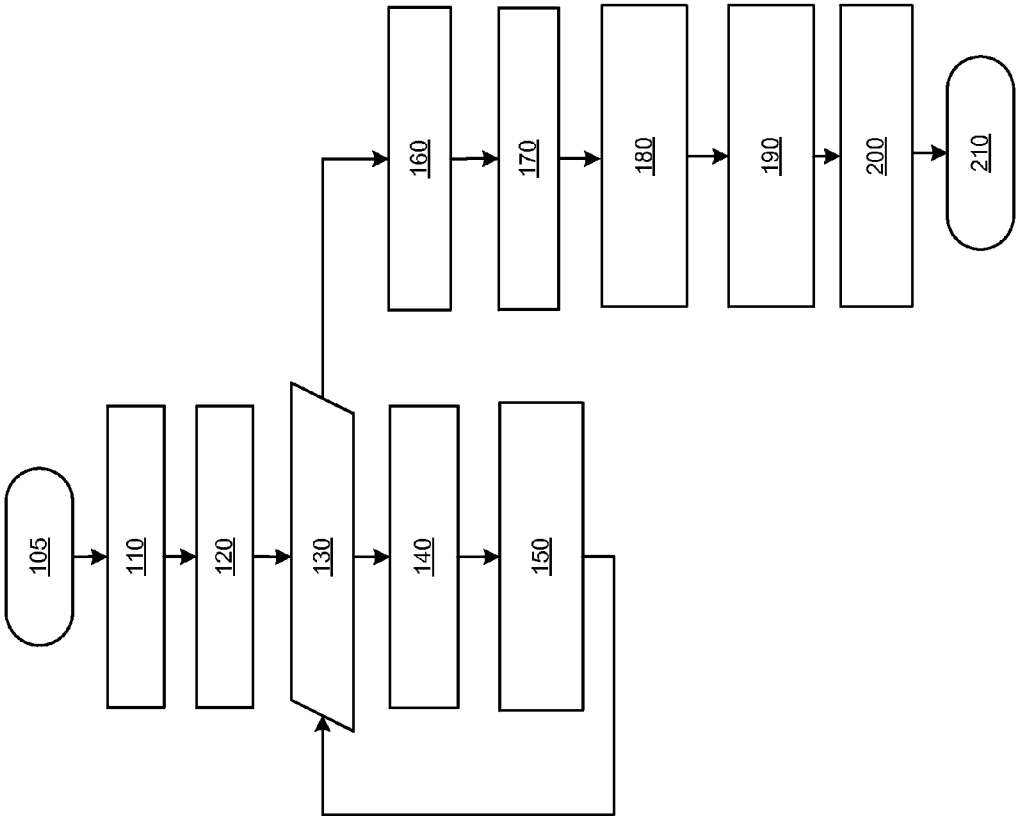


FIG. 3

METHODS AND SYSTEMS FOR DECISION SUPPORT

TECHNICAL FIELD

[0001] The technical field generally relates to methods and systems for providing decision support and in particular to methods and systems for providing recommendations and decision support in an automotive context.

BACKGROUND

[0002] Various vehicle systems make recommendations to a user of the vehicle. For example, a navigation system may make a recommendation of destinations, time to destination, mileage, etc. In another example, automated or semi-automated driving systems may make recommendations of a particular speed or driving maneuver that is being performed or that can be performed by the vehicle. The user is notified of these recommendations and typically makes a decision of whether or not to follow the recommendation. The user typically makes the decision based on his own best judgment.

[0003] Accordingly, it is desirable to provide methods and systems for providing decision support with the recommendations and presenting the recommendations and the decision support to a user of the vehicle. In addition, other desirable features and characteristics of the present invention will become apparent from the subsequent detailed description and the appended claims, taken in conjunction with the accompanying drawings and the foregoing technical field and background.

SUMMARY

[0004] Methods and systems are provided for providing decision support. In one embodiment, a method includes: receiving a recommendation associated with a vehicle; receiving contextual data associated with the vehicle; determining a risk factor based on the recommendation and the contextual data; and generating notification data based on the risk factor to notify a user of the vehicle of the risk factor associated with the recommendation.

[0005] In one embodiment, a system includes a first module and a second module. The first module determines a risk factor based on a recommendation associated with a vehicle and contextual data associated with the vehicle. The second module generates notification data based on the risk factor to notify a user of the vehicle of the risk factor associated with the recommendation.

DESCRIPTION OF THE DRAWINGS

[0006] The exemplary embodiments will hereinafter be described in conjunction with the following drawing figures, wherein like numerals denote like elements, and wherein:

[0007] FIG. **1** is a functional block diagram of a recommendation system that is implemented in a vehicle in accordance with various embodiments;

[0008] FIG. **2** is a dataflow diagram illustrating a control module of the recommendation system in accordance with various embodiments; and

[0009] FIG. **3** is a flowchart illustrating recommendation methods that may be performed by the recommendation system of FIG. **1** in accordance with various embodiments.

DETAILED DESCRIPTION

[0010] The following detailed description is merely exemplary in nature and is not intended to limit the application and uses. Furthermore, there is no intention to be bound by any expressed or implied theory presented in the preceding technical field, background, brief summary or the following detailed description. It should be understood that throughout the drawings, corresponding reference numerals indicate like or corresponding parts and features. As used herein, the term module refers to any hardware, software, firmware, electronic control component, processing logic, and/or processor device, individually or in any combination, including without limitation: application specific integrated circuit (ASIC), an electronic circuit, a processor (shared, dedicated, or group) and memory that executes one or more software or firmware programs, a combinational logic circuit, and/or other suitable components that provide the described functionality.

[0011] FIG. **1** is a functional block diagram of a vehicle **10** that includes a recommendation system **12** in accordance with various embodiments. As can be appreciated, the exemplary vehicle **10** may be an automobile, an aircraft, a spacecraft, a watercraft, a sport utility vehicle, or any other type of vehicle. Although the figures shown herein depict an example with certain arrangements of elements, additional intervening elements, devices, features, or components may be present in actual embodiments. It should also be understood that FIG. **1** is merely illustrative and may not be drawn to scale.

[0012] As shown, the vehicle **10** includes one or more vehicle systems **14-18** including, but not limited to, a steering system, a powertrain system, a heating and cooling system, an infotainment system, or any vehicle system. Each vehicle system **14-18** generally includes one or more sensors **20** that sense observable conditions of the vehicle **10**, one or more mechanical or electro-mechanical components **24**, and one or more actuators **26** that control the one or more electro-mechanical components **24** of the vehicle **10**.

[0013] One or more control modules **28-32** may be associated wither the vehicle systems **14-18**. For example, a single control module **28** may be associated with a single vehicle system **14** (as shown), a single control module **28** may be associated with all of the vehicle systems **14-18**, or multiple control modules **28**, **30** may be implemented for one or a combination of vehicle systems **14-18**. In any of the examples, the control modules **28-32** generally receive sensor signals from the sensors **20** and generate control signals to the actuators **26** based on the sensor signals. When the vehicle **10** includes multiple control modules **28-32** (as shown), the control modules **28-32** communicate over a vehicle communication bus **34**.

[0014] In various embodiments, at least one of the control modules **28** includes a recommendation module **36**; and at least one of the control modules **28** includes a risk factor determination module **38**. For exemplary purposes, the control module **28** is shown to include both the recommendation module **36** and the risk factor determination module **38**. As can be appreciated, in various embodiments the recommendation module **36** and the risk factor determination module **38** can be implemented in separate control modules (not shown). As can further be appreciated, the recommendation module **36** and/or the risk factor determination module **38** can each be implemented for each control module **28-32**, can be implemented for a combination of control modules **28-32**, and/or can be implemented for all control modules **28-32**.

[0015] The recommendation module **36** processes data from the sensors **20** and/or data received from other control modules **30-32** to produce a recommendation. The recommendation may be, for example, a suggestion to perform a particular driving maneuver (e.g., a speed, a passing maneuver, a parking maneuver, etc.), a suggestion that a particular driving maneuver has been detected as being performed (e.g., a speed, a passing maneuver, a parking maneuver, etc.), navigation information (e.g., a destination, a time to destination, etc.), or any other information that may be presented to a driver for evaluation.

[0016] The risk factor determination module **38** receives the recommendation and notifies a user of the vehicle **10** of a risk factor associated with the recommendation. The risk factor indicates a confidence in the recommendation, or a risk level in relation to some aspect that is associated with the recommendation. The risk factor determination module **38** determines the risk factor based on contextual data associated with the recommendation. The contextual data may include, but is not limited to, vehicle data (e.g., vehicle speed, acceleration, etc.), ambient conditions associated with the vehicle **10** (e.g., weather conditions, visibility, traffic information, road type, etc.), and/or driver data (e.g., driver detected fatigue, driver preferences, etc.). The risk factor determination module **38** notifies the user of the risk factor of the recommendation by generating control signals and/or data messages to one or more notification devices **40-44** of the vehicle **10**. The notification devices **40-44** may include, but are not limited to, a display device, an audio device, and/or a haptic device that is associated with or separate from one of the vehicle systems **14-18** or other vehicle element.

[0017] As can be appreciated, the display device may be a display screen (e.g., a screen of an infotainment system or other system), a heads-up display that is projected on a windshield or other location of the vehicle **10**, or a display indicator of a cluster or other system of the vehicle **10**. The audio device may be an audio speaker of an infotainment system or other system of the vehicle **10**. The haptic device may be a vibration device or other sensory device of a seat system, a steering system, an infotainment system, or other system of the vehicle **10**.

[0018] Referring now to FIG. **2** and with continued reference to FIG. **1**, a dataflow diagram illustrates the risk factor determination module **38** in accordance with various embodiments. Various embodiments of the risk factor determination module **38** according to the present disclosure may include any number of sub-modules. As can be appreciated, the sub-modules shown in FIG. **2** may be combined and/or further partitioned to similarly process contextual data to provide a risk factor associated with a particular recommendation. Inputs to the risk factor determination module **38** may be received from the sensors **20** of the vehicle **10**, received from other control modules **30-32** of the vehicle **10**, and/or determined by other sub-modules (not shown) of the control module **28**. In various embodiments, the risk factor determination module **38** includes a data source score determination module **50**, a risk factor determination module **52**, a notification data generation module **54**, a scoring rules data datastore **56**, and a risk factor rules data datastore **58**.

[0019] The data source score determination module **50** receives as input one or more recommendations **60**, and contextual data **62** associated with the one or more recommendations **60**. For exemplary purposes, the disclosure will be discussed in the context of a single recommendation being provided. As discussed above, the recommendation **60** may be determined by a control module **28-32** and may include, for example, a driving maneuver (e.g., a speed, a passing maneuver, a parking maneuver, etc.), navigation information (e.g., a destination, a time to destination, etc.), or other information that may be presented to a driver for evaluation. As discussed above, the contextual data **62** may include vehicle data (e.g., vehicle speed, acceleration, etc.), ambient conditions associated with the vehicle **10** (e.g., weather conditions, visibility, traffic information, road type, etc.), and/or driver data (e.g., driver detected fatigue, driver preferences, etc.).

[0020] The data source score determination module **50** determines a score **64** for each data source of the contextual data **62**. When multiple recommendations **60** are provided, the data source score determination module **50** determines a score **64** for each data source of the contextual data **62** that is associated with each recommendation **60**. The data source score determination module **50** determines the score **64** based on scoring rules **66** stored in the scoring rules data datastore **56**. The scoring rules data datastore **56** may store one or more scoring rules **66** for each data source. For example, the scoring rules **66** are defined for each data source in relation to a parameter the data source measures. The scoring rules **66** may be based on a peak value of the parameter, an average value of the parameter, a defined curve of the parameter, or a summation of the parameter.

[0021] For example, given contextual data **62** that includes data from three data sources associated with the recommendation: data source (a), data source (b), and data source (c), scoring rules **66** for each of the data sources (a), (b), and (c) are retrieved from the scoring rules data datastore **56**. The data for the data source (a) is evaluated according to the rules **66** associated with the data source (a). The data for the data source (b) is evaluated according to the rules **66** associated with the data source (b). The data for the data source (c) is evaluated according to the rules **66** associated with the data source (c).

[0022] Say, for example, data source (a) is vehicle speed, data source (b) is road type, and data source (c) is weather, and each data source is given a score between one and five. The score **64** for (a) can be determined based on scoring rules **66** defining varying speed-range thresholds. For example, if Xkm/h<a<Ykm/h, set score to 1; if Ykm/h<a<Zkm/h set score to 2; and so on. The score **64** for (b) can be determined based on scoring rules **66** defining road types (e.g., straight road, curvature, etc.) and conditions (e.g., ditches, roadworks, single/multi-lane, etc.). For example, if the road is perfectly straight with perfect conditions, set score to 1; if the road type has minor curvature and/or minor ditches, set score to 2; if the road type has major curvature, set score to 3, 4, or 5, depending on the degree of curvature; and if the road type has significant road-conditions such as a single lane and/or road works, set score to 3, 4, or 5, in respect to its severity. The score **64** for (c) can be determined based on scoring rules **66** defining the weather conditions. For example, if the sun is shining and there is perfectly clear visibility, set score to 1; if there is a light drizzle of rain, but clear visibility, set score to 2; if the road is damp and there is fog/rain/snow, set score to 3, 4, or 5 respectively.

[0023] The risk factor determination module **52** receives as input the individual scores **64** for each of the data sources, and the recommendation **60**. The risk factor determination module **52** uses the individual scores **64** to determine an overall risk factor **68** for the recommendation **60**. When multiple

recommendations **60** are provided, the risk factor determination module **52** determines an overall risk factor **68** for each recommendation **60** based on the associated scores **64**.

[0024] The risk factor determination module **52** determines the risk factor **68** based on risk factor rules **70** stored in the risk factor rules data datastore **58**. The risk factor rules data datastore **58** may store one or more risk factor rules **70** for each recommendation **60**. The risk factor rules **70** are defined for each recommendation **60** in relation to the scores **64**. The risk factor rules **70** may define one or more levels of risk for each recommendation **60**. Each level of risk may correspond to a range of numerical values determined by the scores **64** of the associated data sources. For example, a summation of the scores **64** may be computed and the summation may be evaluated by the rules **70**.

[0025] For example, say there are three levels of risk, risk level (1), risk level (2), and risk level (3). The risk factor rules **70** define a numerical range for each level of risk. Provided an example with five contextual data sources the risk factor rules **70** may include: when the summation X is in the range $X \epsilon [5, 6, \ldots, 15]$, set the risk factor to risk level (1); when the summation X is in the range $X \epsilon [16, \ldots, 20]$, set the risk factor to risk level (2); and when the summation X is in the range $X \epsilon [21, \ldots, 25]$, set the risk factor to risk level (2).

[0026] The notification data generation module **54** receives as input the recommendation **60**, and the risk factor **68**. The notification data generation module **54** generates notification data **72** that is used for notifying the user of the recommendation **60** and the risk factor **68** or simply notifying the user of the risk factor **68**. When multiple recommendations **60** and risk factors **68** are provided, the notification data generation module **54** sorts or filters the recommendations **60** based on the risk factors **68**. For example, only recommendations having top risk factors **68** (e.g., a top, a top two, a top three, or other number) may be included in the notification data **72**. The notification data **72** can include, but is not limited to, display data for displaying the information on the display device, auditory data for announcing the information on the audio device, or haptic data for presenting the information haptically via the haptic device.

[0027] In various embodiments, when the notification data **72** includes display data, the display data causes a textual representation of the risk factor **68** and/or the recommendation **60** to be displayed, causes a textual representation of the recommendation **60** to be displayed and a graphical representation of the risk factor **68** to be displayed, causes a graphical representation of the recommendation **60** to be displayed and a textual representation of the risk factor **68** to be displayed, or causes a graphical representation of the risk factor **68** and/or the recommendation **60** to be displayed. For example, the recommendation **60** can be textually displayed in a first text box and a value of the risk factor **68** can be textually displayed in the same or other text box. In various embodiments, the graphical representation of the risk factor **68** may include a gauge or other graphical indicator that displays the risk factor on a numerical or other scale, such as, one provided by color. In various embodiments, the risk factor **68** may include an image associated with the risk levels, or a highlighting of an existing image in a particular color, shading, or boldness associated with the risk levels.

[0028] Referring now to FIG. **3** and with continued reference to FIGS. **1-2**, flowcharts illustrate recommendation methods that may be performed by the recommendation system **12** in accordance with various embodiments. As can be appreciated in light of the disclosure, the order of operation within the methods is not limited to the sequential execution as illustrated in FIG. **3**, but may be performed in one or more varying orders as applicable and in accordance with the present disclosure. As can further be appreciated, one or more steps of the methods may be added or removed without altering the spirit of the method.

[0029] In one example, the method may begin at **105**. The recommendation(s) **60** is determined at **110**. The contextual data **62** associated with the recommendation(s) **60** is determined at **120**. For each data source/parameter in the contextual data **60** at **130**, the scoring rules **66** for the data source are retrieved from the scoring rules data datastore **56** at **140**, and the parameter from the data source is evaluated according to the scoring rules **66** to determine a score **64** at **150**. Once all of the scores **64** are determined at **130**, the risk factor **68** is determined based on the scores **64** at **160-180**.

[0030] For example, as summation of the scores **64** is computed at **160** and the risk factor rules **70** associated with the recommendation **60** are retrieved from the risk factor rules data datastore **58** at **170**. The summation is then evaluated based on the risk factor rules **70** to determine the risk factor **68** at **180**. As can be appreciated, when multiple recommendations **60** are provided at **110**, steps **120-180** can be repeated (flow not shown) for each recommendation **60**.

[0031] The notification data **72** is then determined and generated based on the recommendation(s) **60** and the risk factor (s) **68** at **190**. When multiple recommendations are provided, optionally, the recommendations **60** can be sorted and/or filtered based on the risk factors **68** before the notification data **72** is determined. The notification device(s) **40-44** receives the notification data **72** and notifies the user of the recommendation(s) **60** and/or the risk factor(s) **68** at **200**. Thereafter, the method may end at **210**.

[0032] Those of skill in the art will appreciate that the various illustrative logical blocks, modules, and algorithm steps described in connection with the embodiments disclosed herein may be implemented as electronic hardware, computer software, or combinations of both. Some of the embodiments and implementations are described above in terms of functional and/or logical block components (or modules) and various processing steps. However, it should be appreciated that such block components (or modules) may be realized by any number of hardware, software, and/or firmware components configured to perform the specified functions. To clearly illustrate this interchangeability of hardware and software, various illustrative components, blocks, modules, circuits, and steps have been described above generally in terms of their functionality. Whether such functionality is implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system. Skilled artisans may implement the described functionality in varying ways for each particular application, but such implementation decisions should not be interpreted as causing a departure from the scope of the present invention. For example, an embodiment of a system or a component may employ various integrated circuit components, e.g., memory elements, digital signal processing elements, logic elements, look-up tables, or the like, which may carry out a variety of functions under the control of one or more microprocessors or other control devices. In addition, those skilled in the art will appreciate that embodiments described herein are merely exemplary implementations

[0033] The steps of a method or algorithm described in connection with the embodiments disclosed herein may be embodied directly in hardware, in a software module executed by a processor, or in a combination of the two. A software module may reside in RAM memory, flash memory, ROM memory, EPROM memory, EEPROM memory, registers, hard disk, a removable disk, a CD-ROM, or any other form of storage medium known in the art. An exemplary storage medium is coupled to the processor such the processor can read information from, and write information to, the storage medium. In the alternative, the storage medium may be integral to the processor. The processor and the storage medium may reside in an ASIC. The ASIC may reside in a user terminal. In the alternative, the processor and the storage medium may reside as discrete components in a user terminal.

[0034] In this disclosure, relational terms such as first and second, and the like may be used solely to distinguish one entity or action from another entity or action without necessarily requiring or implying any actual such relationship or order between such entities or actions. Numerical ordinals such as "first," "second," "third," etc. simply denote different singles of a plurality and do not imply any order or sequence unless specifically defined by the claim language. The sequence of the text in any of the claims does not imply that process steps must be performed in a temporal or logical order according to such sequence unless it is specifically defined by the language of the claim. The process steps may be interchanged in any order without departing from the scope of the invention as long as such an interchange does not contradict the claim language and is not logically nonsensical.

[0035] While at least one exemplary embodiment has been presented in the foregoing detailed description, it should be appreciated that a vast number of variations exist. It should also be appreciated that the exemplary embodiment or exemplary embodiments are only examples, and are not intended to limit the scope, applicability, or configuration of the disclosure in any way. Rather, the foregoing detailed description will provide those skilled in the art with a convenient road map for implementing the exemplary embodiment or exemplary embodiments. It should be understood that various changes can be made in the function and arrangement of elements without departing from the scope of the disclosure as set forth in the appended claims and the legal equivalents thereof.

What is claimed is:

1. A method of providing decision support, comprising:
receiving a recommendation associated with a vehicle;
receiving contextual data associated with the vehicle;
determining a risk factor based on the recommendation and the contextual data; and
generating notification data based on the risk factor to notify a user of the vehicle of the risk factor associated with the recommendation.

2. The method of claim **1**, wherein the recommendation includes a driving maneuver.

3. The method of claim **1**, wherein the recommendation includes navigation information.

4. The method of claim **1**, wherein the contextual data includes vehicle data.

5. The method of claim **1**, wherein the contextual data includes ambient conditions associated with the vehicle.

6. The method of claim **1**, wherein the contextual data includes driver data.

7. The method of claim **1**, wherein the contextual data is associated with a plurality of data sources, and wherein the determining the risk factor comprises determining a score for each data source associated with the contextual data, and determining the risk factor based on the scores for each data source.

8. The method of claim **7**, wherein the determining the score for each data source is based on a scoring rules that are associated with the data source.

9. The method of claim **8**, wherein the determining the risk factor further comprises computing a summation of the scores and setting the risk factor based on the summation of the scores.

10. The method of claim **9**, wherein the setting the risk factor is based on risk factor rules that are associated with the recommendation.

11. The method of claim **1**, wherein the notification data comprises display data to display the risk factor to the user.

12. The method of claim **1**, wherein the notification data comprises audio data to play the risk factor to the user.

13. The method of claim **1**, wherein the notification data comprises haptic data to haptically provide the risk factor to the user.

14. A system for of processing data, comprising:
a first module that determines a risk factor based on a recommendation associated with a vehicle and contextual data associated with the vehicle; and
a second module that generates notification data based on the risk factor to notify a user of the vehicle of the risk factor associated with the recommendation.

15. The system of claim **14**, wherein the recommendation includes at least one of a driving maneuver and navigation information.

16. The system of claim **14**, wherein the contextual data includes at least one of vehicle data, ambient conditions associated with the vehicle, and driver data.

17. The system of claim **14**, wherein the contextual data is associated with a plurality of data sources, and wherein the first module determines the risk factor by determining a score for each data source associated with the contextual data, and determining the risk factor based on the scores for each data source.

18. The system of claim **17**, wherein the first module determines the score for each data source based on a scoring of rules that are associated with the data source.

19. The system of claim **17**, wherein the first module determines the risk factor further by computing a summation of the scores and setting the risk factor based on the summation of the scores.

20. The system of claim **19**, wherein the first module sets the risk factor based on risk factor rules that are associated with the recommendation.

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