Predictive Road Safety Alert System

ABSTRACT

This disclosure describes techniques to automatically provide alerts to users driving a vehicle when unsafe driving conditions may soon occur. An alert is determined based on vehicle speed and road conditions such as tight curves, pavement conditions, and weather, and with user permission, based on an ascertained skill of the user driving the vehicle as indicated by past driving occurrences. Safe speeds to handle upcoming road conditions can also be output. Described features provide information and guidance regarding appropriate driving speeds based on road conditions, vehicle characteristics, and driver ability.

KEYWORDS

- Digital map
- Road condition
- Road safety
- Speed limit
- Vehicle safety
- Motorcycle riding
- Navigation assistance
- Lean angle
- Remote roads

BACKGROUND

Many vehicle accidents, especially motorcycle accidents, are caused by the driver's inability or error in judging the difficulty of driving on a road as compared to their own driving capabilities and the physical limitations of their vehicle. This results in many severe accidents.

Devices such as smartphones and car navigation systems are very popular and are used by many drivers for functions such as displaying a map including the current location of the vehicle, providing directions to a destination, and other navigation information such as lane
information, speed limits, warnings about ongoing road work, etc. Some navigation systems are able to generate warnings automatically when a vehicle exceeds a posted speed limit. Some systems are also able to alert the driver of road conditions (e.g., snow, wet road surface, etc.) and dangers that have been shared by other road users. In addition, physical road signs may alert the drivers of conditions such as upcoming curves and safe speeds to navigate those curves.

These technologies do not provide warnings in many common driving situations. For example, one situation is driving on remote roads, which is common for some vehicles such as motorcycles. Wireless communication is often not always available in remote areas, which prevents alert features that are based on immediate information received from sources such as real-time sharing between users. Furthermore, remote roads may not have as many signs to direct the user in comparison to frequently driven roads. In another common situation, roads may change suddenly in the tightness of a curve. For example, a road can have a gentle curve, and then suddenly a sharp curve with no sign. A driver may get used to one degree of curvature of the road and not identify how sharp a particular turn is, potentially resulting in an accident if the vehicle is traveling at a high speed. In addition, displayed or posted speed limits and signs are not related to the driving skills of each driver. Curve speed limits are typically very conservative to remain safe for new drivers, less skilled drivers, and/or various weather conditions, while a skilled driver can navigate a curve at faster speeds.

DESCRIPTION

This disclosure describes features that enable a device, e.g., an in-vehicle navigation system, instrument cluster, standalone navigation devices, smartphones with digital map and navigation applications, etc. to provide vehicle alerts related to unsafe vehicle speeds for upcoming road conditions. Information is presented to the driver if such conditions are
determined by the device to be unsafe at the current vehicle speed. The information can be in the form of alerts and/or guidance that can improve the safety of vehicle travel through the detected conditions.

Instead of the user relying on infrastructure (e.g., road signs) to know upcoming road conditions, the system can use digital map data in combination with the vehicle location (e.g., obtained via GPS) and other obtained data to determine unsafe conditions. However, the alert system does not need an internet connection at the time of the alert. In addition, if the user permits, the system can learn the skill level of the specific user, which informs the system as to what is an unsafe speed for particular road conditions and is able to personalize guidance to the capabilities of the specific user.

The techniques described herein are implemented upon specific user permission to determine and access a user’s data, e.g., user driving characteristics, location, history of driving occurrences, etc. Users are provided with options to grant permissions to and/or to disable features entirely. The user can enable or disable techniques discussed herein for particular vehicles, geographical locations or regions, time periods, or other conditions.

*Training a system to detect unsafe vehicle speeds*

Road safety determinations and alerts can be based on current and upcoming driving conditions, including road conditions (e.g., curve angles, road surface conditions, weather conditions, etc.) and user driving skill (if permitted by the user). In some cases, one or more machine learning models can be trained based on training data that characterizes various driving occurrences for a large number of users. For example, with permission from respective users (or volunteer users who drive routes to generate such data), the training data includes location data that indicates the geographic locations of vehicles, e.g., from GPS sensors on devices in vehicles.
The training data also includes vehicle speed data, which can be obtained from location data and time data to determine velocity, or from vehicle systems (e.g., speedometers).

The training data also includes road conditions of these driving occurrences. For example, the tightness of a traversed curve can be determined based on map data, and/or based on a path of a vehicle through a curve. In some cases, more detailed information is also obtained if available, including altitude and/or banking information about curves, official speed limit data, etc. Other driving conditions can also be obtained, such as pavement condition (e.g., asphalt or gravel), ambient temperature, weather conditions (e.g., rain or snow on roads), etc., which can be obtained from various available data sources and/or by sensors on local devices in vehicles and locally-stored data (e.g., digital map data).

The training data can also include vehicle characteristic data, such as tire pressure of the tires, temperature of vehicle components, and static characteristics such as physical dimensions of the vehicle and wheels, weight of the vehicle, engine characteristics, etc. Some of this data can be obtained from various vehicle sensors (pressure gauges, thermometers, etc.), if available. Vehicle characteristic data can also include a lean angle of a motorcycle while traveling on a curve, which can be sensed via sensors on a device (e.g., accelerometer, gyroscope, etc.).

Based on the training data, machine learning model(s) can be initially trained to output an estimated safe speed that is based on input data that describes driving characteristics as described above. These models can be initially trained as baseline models to determine safe vehicle speeds of a driver of average skill.

In some cases, with the user’s permission, machine learning models implemented on a specific user’s device(s) can be further trained with training data related to the skill of a specific user and related to the particular vehicle used by that user. Such training is performed on-device
with user-permitted data. The user training data can include driving characteristics indicating
driving skill and/or preferences of the specific user. For example, the training data can indicate
the user’s vehicle speed through various radiuses of different road curves at different driving
occurrences, thus allowing the model to learn speeds at which the specific user is comfortable
driving for various types of road conditions including road curve radius, pavement type, weather,
etc. The speed of the user’s comfortable driving can be used as a safe speed indicator, e.g., can
be used as a baseline from which a safe speed is determined.

In some cases, the specific user’s vehicle characteristics can be included in training data
for the models, including physical dimensions, model and year, engine type, etc. Specific vehicle
dynamics information, and/or mathematical and physical models of vehicles, can be used in
some cases to fine tune the models and/or other algorithms.

In addition, for motorcycles, lean angle information can be included in the training data.
A limit to safe driving through a road curve might not be just a given speed but also a given lean
angle of the motorcycle. In general, novice riders are less able to lean their motorcycle than
advanced riders, resulting in less turning capability. If lean angle data is available (e.g., from
sensors on a device), a dynamic model of leaning can be built based on training data indicating
that the user leans particular amounts in various curve radiuses. This model can be included in
the machine learning models. In some cases, the dynamic model can include a physical limit to
lean angle for the user’s motorcycle, e.g., based on specific characteristics of the user’s
motorcycle or on an average capability of motorcycles.

In this way, with the user’s permission, the user’s particular driving skill can be
incorporated into the machine learning models and updated as user skill changes. For example,
for certain road conditions, if the average user is safe going 20 mph, the specific user may be a
beginner who is only safe below 15 mph, and the model learns this characteristic. The model may adjust over time based on new training data as the specific user gains experience and 20 mph becomes a safe speed for the user driving in those same road conditions. The model is implemented in a manner that chooses the safe speed based on a confidence threshold, and such that the chosen safe speed is within legal speed limits or guidance provided by authorities. In case of multiple plausible answers, the lowest safe speed is chosen.

The configuration of the system can be automated, e.g., it can learn which speeds are safe based on automatic monitoring the speed of the vehicle and other driving conditions, and/or the system can be configured manually based on user-input data and preferences.

Providing Alerts Based on Unsafe Driving Conditions

The alert system can use the above machine learning models to determine whether the current speed of the user’s vehicle is safe for current and/or upcoming driving conditions. Alerts are output by a device if the vehicle is approaching a road condition, such as a curve, at a speed deemed unsafe based on the current driving conditions including the user’s known driving capabilities.

With user permission, current vehicle location data is obtained (e.g., via GPS sensor) to determine upcoming road conditions, such as curves, slopes, pavement conditions, etc. For example, the radius of a road curve which the user is approaching can be determined. This can include determining multiple radiuses for a single curve, e.g., if the radius of the curve changes (which is often a difficult or dangerous driving condition). In some cases, a banking angle, slope, changes of altitude, and/or official speed limit of the road curve can be determined, e.g., based on available map data. A slope of an approaching straight road or other type of road section can also be determined.
Further, a pavement condition of the upcoming road section is also determined. For example, it is determined whether a road curve has asphalt in the near part of the curve and gravel in the last part of the curve. Weather conditions of the upcoming road section can also be determined. In some cases, locally-stored digital map data may indicate these characteristics of the upcoming road section. For example, map data of the region, or only map data relevant to roads that the user will travel, may have been wirelessly downloaded to local storage of the device when an internet connection was previously available.

In addition, the current speed of the vehicle is determined based on speedometer data or based on changes in vehicle location over time. Vehicle data can also be obtained, such as current engine temperature, tire pressure, etc. If the vehicle is a motorcycle, a current lean angle of the motorcycle can be determined from motion sensors that may be in the device or vehicle.

This data indicating the current and upcoming driving conditions is provided as input to the machine learning model(s). The machine learning models determine whether the input data indicates an unsafe condition. For example, the current speed of the vehicle, road conditions, vehicle data, etc. are processed by the machine learning models to obtain the output. In some cases, the machine learning models output can be an estimated maximum speed of the vehicle that would be safe for the upcoming driving conditions. The models can take into account the user’s skill level based on the training data as described above.

If an unsafe speed is determined, the device outputs an alert. In various examples, the alert can be a visual alert, e.g., displayed on a display of the device (and/or streamed over a local wireless connection from a vehicle navigation system to the user device). In some cases, the alert can include an audio alert output by speakers connected to the device.
Fig. 1 shows an example device display (100) that includes an alert output to warn the user of a current unsafe speed based on upcoming driving conditions.

![Warning Sign](image)

**Fig. 1: Example display of alert indicating unsafe driving speed**

The alert includes a warning (101) that instructs the user to slow down the vehicle because of an upcoming tight curve. It has been determined that the user’s vehicle is currently moving too fast and may not be able to navigate the curve safely. A warning can also or alternatively be output as audio on speakers, e.g., as an alarm or other conspicuous sound. Furthermore, in some cases, the alert can include a graphical representation (102) including the vehicle (103) and the upcoming curve that includes a tight section (104) indicated to be difficult or dangerous (e.g., displayed in red). The alert also can include a distance (105) ahead to the tight section of the curve, and/or can include a suggested speed (106) that is safe to navigate the curve based on current road conditions.

The determination to output the warning is based in part on the radius of the curve, which is determined to be too tight for safely traversing based on current user speed, road conditions (e.g., road surface and weather), and the user’s skill as indicated by previous driving occurrences through similar curves. In addition, the alert is triggered due to recognition that the curve has
multiple radiuses such that its radius reduces, e.g., the curve starts off wide but then tightens part way through, which can be difficult to judge and dangerous for driving.

In addition, the determination of when to trigger the alert may be influenced by the amount of reduction in speed (braking) that is needed prior to the vehicle reaching the difficult portion of the curve and the amount of road length needed to achieve that braking, as estimated based on models using vehicle characteristics, current weight, etc. Furthermore, the alert trigger may be influenced by whether the curve is significantly tighter (smaller radius) than previous curves just experienced on the road by the user in the past few miles.

The alert system can be applied to any vehicle type, but can be particularly appropriate for motorcycles and other vehicles that require specialized skill to drive. In one example, a navigation app can include a mode that provides alerts, and/or a motorcycle mode that adjusts alerts accordingly, e.g., triggers alerts more often for conditions particularly difficult to motorcycles. Furthermore, described techniques can also be used to alert drivers of other types of vehicles. For example, a driver of a large semi-truck can be alerted that the truck is going too fast down a steep slope, if the brakes of the truck are sensed to be in danger of overheating or failing based on duration of braking, detected temperature, current speed of the vehicle, the slope of the current and/or upcoming road section, weight of the current load of the truck, etc.

Some systems can provide alerts without use of user driving skill information, e.g., the models can estimate a safe speed based only on road curvature and/or other road conditions. In some cases, alerts can be determined without the use of machine learning models and training data, e.g., by examining map data that indicate road conditions and weather conditions, and/or based on stored indications of user driving skill.
Described techniques can be implemented in a separate app running on a device, or can be built into existing applications, such as a navigation app, a digital map app, a road conditions app, etc. Features can be implemented in vehicle dashboard devices, in a vehicular device with a GPS sensor, or in standalone user devices.

If user permission is obtained, and if a server connection is available, machine learning models described herein can be fully or partially implemented on a server in communication with the device. Model training is performed based on generalized data that is not attributable to individual users, and/or performed, if user permission is obtained, only locally on the user device with user data, e.g., using a federated learning approach. In some cases, heuristics and rules can be used instead of or in addition to machine learning models.

The various features of the system are implemented only with user permission to access user data that serves as input to the system. Users may be provided with controls allowing the user to make an election as to both if and when systems, programs or features described herein may enable collection of user information (e.g., a user’s location, user vehicle characteristics, a user’s driving, a user’s input and commands, a user’s preferences, etc.), and if the user is sent content or communications from a server. Certain techniques are not implemented if users deny permission. In addition, certain data may be treated in one or more ways before it is stored or used, so that personally identifiable information is removed. For example, a user’s identity may be treated so that no personally identifiable information can be determined for the user. Thus, the user may have control over what information is collected about the user, how that information is used, and what information is provided to the user.
CONCLUSION

This disclosure describes techniques to automatically provide alerts to users driving a vehicle when unsafe driving conditions may soon occur. An alert is determined based on vehicle speed and road conditions such as tight curves, pavement conditions, and weather, and with user permission, based on an ascertained skill of the user driving the vehicle as indicated by past driving occurrences. Safe speeds to handle upcoming road conditions can also be output. Described features provide information and guidance regarding appropriate driving speeds based on road conditions, vehicle characteristics, and driver ability. The described techniques can be especially important for driving on remote roads that do not have adequate road signs, and for drivers of vehicles such as motorcycles.