ENHANCED ONBOARD EQUIPMENT

This application is entitled to the benefit of the filing date of United States provisional patent application 62/893,616, filed August 29, 2019, the entire contents of which are incorporated here by reference.

Background

The contents of United States patent 10,235,882 are incorporated here by reference.

This description relates to enhanced onboard equipment.

Collision avoidance systems have become abundant. King et al. (US patent publication 2007/0276600 A1, 2007), for example, described placing sensors ahead of an intersection and applying a physics-based decision rule to predict if two vehicles are about to crash at the intersection based on heading and speed.

In Aoude et al. (USA patent 9,129,519 B2, 2015, the entire contents of which are incorporated here by reference) the behavior of drivers is monitored and modeled to allow for the prediction and prevention of a violation in traffic situations at intersections.

Collision avoidance is the main defense against injury and loss of life and property in ground transportation. Providing early warning of dangerous situations aids collision avoidance.

Summary

In general, in a first aspect, the present disclosure provides an apparatus comprising an equipment for use on board a first ground transportation entity, the equipment having (a) a receiver for information generated by a sensor of the environment of the first ground transportation entity, (b) a processor, and (c) a memory storing instructions executable by the processor to generate and send safety message information to a second ground transportation entity based on the information generated by the one or more sensors.

Implementations may include one or a combination of two or more of the following features. The instructions are executable by the processor to generate a prediction for use in generating the safety message information. The prediction is generated by a predictive model. The predictive model is configured to predict a dangerous situation involving the first ground transportation entity, the second ground transportation entity, or another ground transportation entity. The dangerous situation involves a crossing of a lane of a road by the second ground transportation

entity. The second ground transportation entity includes a vehicle and the dangerous situation includes a skidding across the lane by the vehicle. The second ground transportation entity includes a pedestrian or other vulnerable road user crossing a road. The vulnerable road user is crossing the road at an intersection. The vulnerable road user is crossing the road other than at an intersection. The predicted dangerous situation includes a predicted collision between a third ground transportation entity and the second ground transportation entity. The first ground transportation entity includes a vehicle and the second ground transportation entity includes a pedestrian or other vulnerable road user. The third ground transportation entity is following the first ground transportation entity and a view of the third ground transportation entity from the first ground transportation entity is occluded. The third ground transportation entity is in a lane adjacent a lane in which the first ground transportation entity is traveling. The instructions are executable by the processor to determine motion parameters of a third ground transportation entity. The second ground transportation entity has only an obstructed view of the third ground transportation. The second ground transportation entity includes a pedestrian or other vulnerable road user. The safety message information sent by the processor includes a basic safety message. The safety message information sent by the processor includes a virtual basic safety message. The safety message information sent by the processor includes a personal safety message. The safety message information sent by the processor includes a virtual personal safety message. The safety message information sent by the processor includes a virtual basic safety message sent on behalf of a third ground transportation entity. The third ground transportation entity includes an unconnected ground transportation entity. The safety message information sent by the processor includes a virtual personal safety message sent on behalf of the third ground transportation entity. The equipment has (d) a receiver for information sent wirelessly from a source external to the first ground transportation entity. The apparatus of claim including the first ground transportation entity. The safety message information includes a virtual intersection collision avoidance message (VICA). The safety message information includes an intersection collision avoidance message (ICA). The safety message information includes a virtual combined safety message (VCSM). The safety message information includes a combined safety message (CSM).

In general, in a second aspect, the present disclosure provides an apparatus comprising an equipment for use on board a first ground transportation entity, the equipment having (a) a receiver for first position correction information sent from a source external to the first ground transportation entity, (b) a receiver for information representing a parameter of position or

motion of the first ground transportation entity, (c) a processor, and (d) a memory storing instructions executable by the processor to generate updated position correction information based on the first position correction information and on the information representing the parameter of motion, and send a position correction message to another ground transportation entity based on the updated position correction information.

Implementations may include one or a combination of two or more of the following features. The position correction information sent from the source external to the first ground transportation entity includes a position correction message. The position correction information sent from the source external to the first ground transportation entity includes a radio technical commission for Maritime (RTCM) correction message. The position correction information comprises GNSS position correction. The parameter of position or motion includes a current position of the first ground transportation entity. The source external to the first ground transportation entity includes a RSE or an external service configured to transmit RTCM correction messages over the Internet. The instructions are executable by the processor to confirm a level of confidence in the updated position correction information.

In general, in a third aspect, the present disclosure provides a method comprising receiving information generated by a sensor, mounted on a first ground transportation entity, of the environment of the first ground transportation entity; generating and sending safety message information to a second ground transportation entity based on the information generated by the sensor.

Implementations may include one or a combination of two or more of the following features. A prediction is generated for use in generating the safety message information. The prediction is generated by a predictive model. The predictive model is configured to predict a dangerous situation involving the first ground transportation entity, the second ground transportation entity, or another ground transportation entity. The dangerous situation involves a crossing of a lane of a road by the second ground transportation entity. The second ground transportation entity includes a vehicle and the dangerous situation includes a skidding across the lane by the vehicle. The second ground transportation entity includes a pedestrian or other vulnerable road user crossing a road. The vulnerable road user is crossing the road at an intersection. The vulnerable road user is crossing the road other than at an intersection. The dangerous situation includes a collision between a third ground transportation entity and the second ground transportation

entity. The first ground transportation entity includes a vehicle and the second ground transportation entity includes a pedestrian or other vulnerable road user. The third ground transportation entity is following the first ground transportation entity and a view of the third ground transportation entity from the first ground transportation entity is occluded. The third ground transportation entity is in a lane adjacent a lane in which the first ground transportation entity is traveling. Motion parameters of a third ground transportation entity are determined. The second ground transportation entity has only an obstructed view of the third ground transportation. The second ground transportation entity includes a pedestrian or other vulnerable road user. The safety message information includes a basic safety message. The safety message information includes a virtual basic safety message. The safety message information includes a personal safety message. The safety message information includes a virtual personal safety message. The safety message information includes a virtual basic safety message sent on behalf of a third ground transportation entity. The safety message information sent by the processor includes a virtual personal safety message sent on behalf of the third ground transportation. The third ground transportation entity includes an unconnected ground transportation entity. Information is received that has been sent wirelessly from a source external to the first ground transportation entity. The safety message information includes a virtual intersection collision avoidance message (VICA). The safety message information includes a virtual intersection collision avoidance message (ICA). The safety message information includes a virtual combined safety message (VCSM). The safety message information includes a combined safety message (CSM).

In general, in a fourth aspect, the present disclosure provides a method comprising receiving first position correction information sent from a source external to a first ground transportation entity; receiving information representing a parameter of motion of the first ground transportation entity; generating updated position correction information based on the first position correction information and on the information representing the parameter of motion, and sending a position correction message to another ground transportation entity based on the updated position correction information.

Implementations may include one or a combination of two or more of the following features. The position correction information sent from the source external to the first ground transportation entity includes a position correction message. The position correction information sent from the