

# SYSTEMS AND METHODS FOR CLASSIFYING DRIVER BEHAVIOR

## RELATED APPLICATION

This applications claims priority to U.S. Provisional Patent Application No. 62/726,916, filed on September 4, 2018, entitled “SYSTEMS AND METHODS FOR IMAGE PROCESSING OF TELEMATICS DATA TO CONTEXTUALLY CLASSIFY DRIVER BEHAVIOR, the entire contents of which are incorporated here by reference.

## TECHNICAL FIELD

This disclosure generally describes telematics, specifically vehicle telematics.

## BACKGROUND

Telematics can refer to the field of sending, receiving, and storing data related to telecommunication devices, global positioning system (GPS) devices, or other such sensors for the purpose of controlling, observing, analyzing, or otherwise interacting with a remote device related to those sensors. In some cases, one or more sensors providing telematics data can be related to a vehicle, such as an automobile. The telematics data provided by the sensors can be used to observe the behavior of the vehicle and the vehicle's driver.

## SUMMARY

In a first aspect, the present disclosure provides a data processing system comprising: one or more processors; and memory storing instructions executable by the one or more processors to coordinate (a) detection of at least one event of interest that may have occurred at a vehicle during one or more times from position, speed or acceleration data captured by one or more sensors at the vehicle, with (b) processing of a combination of the position, speed or acceleration data captured by the one or more sensors at the vehicle during the one or more times and image data captured by a camera at the vehicle during the one or more times to determine a predicted likelihood of the at least one event of interest having occurred, the stored instructions that are executable by the one or more processors to coordinate (a) with (b) comprising stored

instructions executable by the one or more processors to: electronically receive the position, speed, or acceleration data captured by the one or more sensors at the vehicle; process the position, speed, or acceleration data to detect data indicative of at least one event of interest that may have occurred at the vehicle during the one or more times; in response to detection of the data indicative of the at least one event of interest, process a combination of the position, speed, or acceleration data captured by the one or more sensors at the vehicle during the one or more times and image data captured by the camera at the vehicle during the one or more times, including: electronically receive the image data captured by the camera at the vehicle during the one or more times; combine the image data captured during the one or more times and the position, speed, or acceleration data captured during the one or more times to generate and electronically store collective data representing the at least one event of interest; and determine, based at least partly on the electronically stored collective data, a prediction value indicative of a predicted likelihood of the at least one event of interest having occurred.

In a second aspect, the present disclosure provides a computer-implemented method comprising: receiving position, speed, or acceleration data captured by one or more sensors at a vehicle; processing the position, speed, or acceleration data to detect data indicative of at least one event of interest at the vehicle that may have occurred during one or more times; in response to detection of the data indicative of the at least one event of interest, processing a combination of the position, speed, or acceleration data captured by the one or more sensors at the vehicle during the one or more times and image data captured by a camera at the vehicle during the one or more times, including: receiving the image data captured by the camera at the vehicle during the one or more times; combining the image data captured during the one or more times and the position, speed, or acceleration data captured during the one or more times to generate and store collective data representing the at least one event of interest; and generating, based at least partly on the stored collective data, a prediction value indicative of a predicted likelihood of the at least one event of interest having occurred.

In a third aspect, the present disclosure provides a non-transitory computer-readable storage medium having instructions executable by one or more processors to

cause the processors to perform operations comprising: electronically receiving position, speed, or acceleration data captured by one or more sensors at a vehicle; processing the position, speed, or acceleration data to detect data indicative of at least one event of interest that may have occurred at the vehicle during one or more times; in response to detection of the data indicative of the at least one event of interest, processing a combination of the position, speed, or acceleration data captured by the one or more sensors at the vehicle during the one or more times and image data captured by a camera at the vehicle during the one or more times, including: electronically receiving the image data captured by the camera at the vehicle during the one or more times; combining the image data and the position, speed, or acceleration data to generate and electronically store collective data representing the at least one event of interest; and generating, based at least partly on the electronically stored collective data, a prediction value indicative of a predicted likelihood of the at least one event of interest having occurred.

In an aspectexample, a data processing system is provided. The data processing system includes a camera configured to capture image data, one or more sensors configured to capture telematics data, and a feature classification engine configured to generate classification metrics for a feature vector by performing one or more operations. The one or more operations include generating, based at least partly on the image data and telematics data, the feature vector, with the feature vector comprising features representing events of interest of the image data and the telematics data. The one or more operations include determining, using machine learning logic, a classification metric for each feature of the feature vector. The data processing system includes a prediction engine configured to generate a prediction value indicative of a predicted

## WHAT IS CLAIMED IS:

### 1. A data processing system comprising:

one or more processors; and

memory storing instructions executable by the one or more processors to coordinate (a) detection of at least one event of interest that may have occurred at a vehicle during one or more times from position, speed or acceleration data captured by one or more sensors at the vehicle, with (b) processing of a combination of the position, speed or acceleration data captured by the one or more sensors at the vehicle during the one or more times and image data captured by a camera at the vehicle during the one or more times to determine a predicted likelihood of the at least one event of interest having occurred,

the stored instructions that are executable by the one or more processors to coordinate (a) with (b) comprising stored instructions executable by the one or more processors to:

electronically receive the position, speed, or acceleration data captured by the one or more sensors at the vehicle;

process the position, speed, or acceleration data to detect data indicative of at least one event of interest that may have occurred at the vehicle during the one or more times;

in response to detection of the data indicative of the at least one event of interest, process a combination of the position, speed, or acceleration data captured by the one or more sensors at the vehicle during the one or more times and image data captured by the camera at the vehicle during the one or more times, including:

electronically receive the image data captured by the camera at the vehicle during the one or more times;

combine the image data captured during the one or more times and the position, speed, or acceleration data captured during the one or more times to generate and electronically store collective data representing the at least one event of interest; and

determine, based at least partly on the electronically stored collective data, a prediction value indicative of a predicted likelihood of the at least one event of interest having occurred.

~~a camera configured to capture image data;~~

~~one or more sensors configured to capture telematics data;~~

~~a feature classification engine configured to generate classification metrics for a feature vector by performing operations comprising:~~

~~generating, based at least partly on the image data and telematics data, the feature vector, with the feature vector comprising features representing events of interest of the image data and the telematics data; and~~

~~determining, using machine learning logic, a classification metric for each feature of the feature vector; and~~

~~—— a prediction engine configured to generate a prediction value indicative of a predicted likelihood of one of the events of interest occurring by performing operations comprising:~~

~~assigning to each feature, based at least partly on the classification metric of the respective feature, a prediction weight; and~~

~~determining the prediction value based at least partly on prediction weights for remaining features of the feature vector.~~

2. The system of claim 1, wherein the event of interest comprises a relative speeding event, a following distance event, a traffic density event, a rolling event, a missed stop event, a turning behavior event, a hard stop event, an impaired visibility event, or a crosswalk behavior event.

3. The system of claim 1, wherein the one or more processors are prediction engine is configured to generate a risk score that is associated with a driver of the vehicle based at least partly on the prediction value and the at least one event of interest, wherein the at least one event of interest is associated with a risk, and wherein the risk is adjusted based on the prediction value to generate the risk score for the driver of the vehicle.

~~4. The system of claim 1, wherein the features comprise one or more of a street light, a vehicle, a street sign, or a road marking.~~

~~5. The system of claim 1, wherein the telematics data comprises one or more of acceleration data, position data, and wireless signal strength data.~~

~~64. The system of claim 1, wherein the image data comprises one or more of an image and a series of images.~~

~~75. The system of claim 1, wherein the ~~prediction engine and the feature classification engine~~ one or more processors are part of a mobile device or a vehicle device.~~

~~8. The system of claim 1, wherein the ~~prediction engine and the feature classification engine~~ are part of a vehicle device.~~

96. A computer-implemented method comprising:

receiving position, speed, or acceleration data captured by one or more sensors at a vehicle;

processing the position, speed, or acceleration data to detect data indicative of at least one event of interest at the vehicle that may have occurred during one or more times;

in response to detection of the data indicative of the at least one event of interest, processing a combination of the position, speed, or acceleration data captured by the one or more sensors at the vehicle during the one or more times and image data captured by a camera at the vehicle during the one or more times, including:

receiving the image data captured by the camera at the vehicle during the one or more times;

combining the image data captured during the one or more times and the position, speed, or acceleration data captured during the one or more times to generate and store collective data representing the at least one event of interest; and

generating, based at least partly on the stored collective data, a prediction value indicative of a predicted likelihood of the at least one event of interest having occurred.

~~generating, depending on received image data and telematics data captured during operation of a vehicle, features associated with events of the image data and the telematics data;~~

~~determining a classification metric for each of the features; and~~

~~assigning to each feature, depending on the classification metric of the feature, a prediction weight;~~

~~determining a prediction value depending on prediction weights for the features; and~~

~~generating a predicted likelihood of one of the events occurring depending on the prediction weights.~~

~~107.~~ The method of claim 96, wherein one or more of the image data and the telematics position, speed, or acceleration data are processed by a mobile device to generate pre-processed data, and wherein the pre-processed data are sent to a remote computing environment for further processing.

~~118.~~ The method of claim 96, wherein the events at least one event of interest comprises one or more of a relative speeding event, a following distance event, a traffic density event, a rolling event, a missed stop event, a turning behavior event, a hard stop event, an impaired visibility event, or a crosswalk behavior event.

~~129.~~ The method of claim 96, comprising generating a risk score that is associated with a driver of the vehicle based at least partly on the prediction value and the at least one event of interest, wherein the at least one event of interest is associated with a risk, and wherein the risk is adjusted based on the prediction value to generate the risk score for the driver of the vehicle.

~~13.~~ The method of claim 9, wherein the features comprise one or more of a street light, a vehicle, a street sign, or a road marking.

~~14. The method of claim 9, wherein the telematics data comprises one or more of acceleration data, position data, and wireless signal strength data.~~

~~15. The method of claim 9, wherein the image data comprises one or more of an image or a series of images.~~

~~16~~10. A non-transitory computer-readable storage medium having instructions executable by one or more processors to cause the processors to perform operations comprising:

electronically receiving position, speed, or acceleration data captured by one or more sensors at a vehicle;

processing the position, speed, or acceleration data to detect data indicative of at least one event of interest that may have occurred at the vehicle during one or more times;

in response to detection of the data indicative of the at least one event of interest, processing a combination of the position, speed, or acceleration data captured by the one or more sensors at the vehicle during the one or more times and image data captured by a camera at the vehicle during the one or more times, including:

electronically receiving the image data captured by the camera at the vehicle during the one or more times;

combining the image data and the position, speed, or acceleration data to generate and electronically store collective data representing the at least one event of interest; and

generating, based at least partly on the electronically stored collective data, a prediction value indicative of a predicted likelihood of the at least one event of interest having occurred.

~~receiving, from a camera, image data;~~

~~receiving, from one or more sensors, telematics data;~~

~~generating, by a feature classification engine, classification metrics for a feature vector by performing operations comprising:~~

~~generating, based at least partly on the image data and telematics data, the feature vector, with the feature vector comprising features representing events of interest of the image data and the telematics data;~~  
~~determining, using machine learning logic, a classification metric for each feature of the feature vector; and~~  
~~generating, by a prediction engine, a prediction value indicative of a predicted likelihood one of the events of interest occurring by performing operations comprising:~~  
~~assigning to each feature, based at least partly on the classification metric of the respective feature, a prediction weight; and~~  
~~determining the prediction value based at least partly on prediction weights for remaining features of the feature vector.~~

~~4711.~~ The non-transitory computer-readable storage medium of claim ~~4610~~, wherein one or more of the image data and the ~~telematics position, speed, or acceleration~~ data are processed by a mobile device to generate pre-processed data, and wherein the pre-processed data are sent to a remote computing environment for further processing.

~~4812.~~ The non-transitory computer-readable storage medium of claim ~~4610~~, wherein the ~~at least one~~ event of interest comprises a relative speeding event, a following distance event, a traffic density event, a rolling event, a missed stop event, a turning behavior event, a hard stop event, an impaired visibility event, or a crosswalk behavior event.

~~4913.~~ The non-transitory computer-readable storage medium of claim ~~4610~~, the operations comprising generating a risk score that is associated with a driver ~~of the vehicle~~ based at least partly on the prediction value ~~and the at least one event of interest, wherein the at least one event of interest is associated with a risk, and wherein the risk is adjusted based on the prediction value to generate the risk score for the driver of the vehicle.~~

~~20. The non-transitory computer-readable storage medium of claim 16, wherein the features comprise one or more of a street light, a vehicle, a street sign, or a road marking.~~

14. The system of claim 1, wherein the one or more processors are configured to:

receive information about a context at the vehicle before the one or more times; and

determine whether to process the image data captured by the camera at the vehicle during the one or more times based at least in part on the information about the context at the vehicle before the one or more times.

15. The system of claim 1, wherein the one or more processors are configured to:

generate a feature vector comprising features of the collective data representing at least one event of interest;

determine, using machine learning logic, a classification metric for each feature of the feature vector;

assign to each feature, based at least partly on the classification metric of the respective feature, a prediction weight; and

determine, based at least partly on the collective data and the prediction weights, the prediction value indicative of the predicted likelihood of the at least one event of interest having occurred.

16. The method of claim 6, comprising:

generating a feature vector comprising features of the collective data representing at least one event of interest;

determining, using machine learning logic, a classification metric for each feature of the feature vector;

assigning to each feature, based at least partly on the classification metric of the respective feature, a prediction weight; and

determining, based at least partly on the collective data and the prediction weights, the prediction value indicative of the predicted likelihood of the at least one event of interest having occurred.

17. The non-transitory computer-readable storage medium of claim 10 having instructions executable by the one or more processors to cause the one or more processors to perform operations comprising:

generating a feature vector comprising features of the collective data representing at least one event of interest;

determining, using machine learning logic, a classification metric for each feature of the feature vector;

assigning to each feature, based at least partly on the classification metric of the respective feature, a prediction weight; and

determining, based at least partly on the collective data and the prediction weights, the prediction value indicative of the predicted likelihood of the at least one event of interest having occurred.