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Acceleration/Deceleration Detection System - Creation of Driving Behavior Profiles for Efficiency

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Abstract: Driving behavior is a term used to describe deliberate or accidental activities while a driver drives a vehicle. Driving behavior data is useful for efficiency in the automotive domain, including insurance companies, aftermarkets, production planning, and vehicle servicing. Therefore, the aim of this study is to develop and investigate an Acceleration/Deceleration(A/D) detection system. A/D can be measured using a 3-axis accelerometer. The accelerometer on the vehicle cannot precisely reflect the driver's actual A/D behavior due to its undetermined orientation. Additionally, the accelerometer detects sudden movements. In order to prevent unexpected acceleration and deceleration changes and to achieve the desired driving behavior, a gyroscope has been incorporated into the system. Thus, a driving aid system was developed using the combined data from the gyroscope and accelerometer. Moreover, the A/D detection system reads and combines the vehicle's CAN messages to more stabilize the system. As a result, driving behavior data during vehicle trips is collected and recorded to inform the driver how to have a more efficient driving experience and as well as making the related companies aware of the trips that have been made. Furthermore, they can be combined with service feedback and support the manufacturer's production strategy to increase efficiency.

Keywords: Driving behavior, Acceleration, Deceleration, Driving efficiency

Introduction

The world's transition from a centralized to a decentralized structure is due to the increasing adoption of technologies such as blockchain, distributed ledger, and peer-to-peer networks. One of the most important factors enabling this transition is data. Data is essential for building decentralized systems as it allows for creating distributed databases and establishing consensus mechanisms that ensure the accuracy and validity of data records. This transition has affected the automotive domain as well as the whole sector. Blockchain technology has the potential to revolutionize the automotive industry. This technology offers a number of advantages, including data security, privacy, anonymity, traceability, accountability, integrity, robustness, transparency, reliability, and authentication (Fraga-Lamas et al., 2019, p. 17578). More vehicles are now equipped with sensors that collect and transmit data in real time, with the rise of connected cars and the Internet of Things (IoT). The integration of blockchain into IoT networks is becoming increasingly important in this context (Ahmad et al., 2019). Collecting and analyzing driving behavior data from vehicles provide valuable information for various processes in the automotive field, such as development and production. The driving behavior data is used during the development process to provide a safer and more efficient driving experience for the driver. More than 50% of serious road accidents caused by professional drivers of heavy vehicles are due to risky driving behavior. Quantitative estimation of driving performance and behavior is helpful in measuring the driving risk and internal driving style of professional drivers (He et al., 2022, p. 1). In addition, analyzing

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data contributes to optimizing production performance and increasing productivity. This exemplifies the significance of driving behavior data in the automotive industry. The Acceleration/Deceleration(A/D) Detection System has been developed to create driving behavior profiles for efficiency. Acceleration and deceleration can be detected with a 3-axis accelerometer. However, with this detection method, A/D cannot be determined exactly to the uncertain orientation of the accelerometer. The real A/D behavior data of the driver cannot be collected since sudden movements are detected with this measurement method. The gyroscope is integrated into the A/D Detection System as a solution.

Unexpected acceleration and deceleration changes are prevented thanks to the gyroscope added to the system. In this way, desired driving behavior data was obtained. Data from the gyroscope and accelerometer were used in this study. The CAN messages of the vehicle were read in addition and the system was supported with messages from the CAN-BUS, to make the system more stable. A driving support system has been developed that collects driving behavior data in this way while the vehicle is in motion. Information is given to the driver to provide an efficient driving experience with these collected data, and the data is transmitted to the relevant companies.

Materials

Accelerometer

3-axis accelerometer is a type of micro-electromechanical system (MEMS) device that is capable of measuring acceleration along three perpendicular axes, typically denoted as x, y, and z. The device is composed of a proof mass that is suspended by a set of flexure springs and enclosed within a hermetically sealed package, which can be affixed onto a printed circuit board (“A beginner”, n.d.). Acceleration causes the proof mass to deflect, and this deflection is sensed by mechanisms that convert the mechanical motion into an electrical signal (“What is an accelerometer? (Fierce Electronics, 2023).

The implementation of 3-axis accelerometers in automotive applications has enabled the measurement of acceleration in vehicles, detection of impacts, and provision of feedback for electronic stability control, GPS positioning, and collision detection systems. Within the context of our study on A/D detection systems, the 3-axis accelerometer is utilized to gauge the acceleration and deceleration of the vehicle, as well as to detect changes in slope. Additionally, the device is utilized to determine the orientation of the platform within the vehicle, as the platform may not always be aligned with a consistent direction and may be subject to change based on the slope of the road.

Gyroscope

A gyroscope is an electronic sensor used to detect and measure rotational motion. These devices operate to determine the angular velocity of an object around a fixed axis. Essentially, a gyroscope detects the object's rotational motion by utilizing either the interferometer method or the Coriolis effect (Gill et al., p. 7405). The fundamental principle behind the operation of gyroscopes acknowledges that an object's rotational motion is governed by Newton's laws of conservation. An object maintains a certain angular momentum (angular velocity), and if the rotational speed changes, so does the angular momentum. This principle forms the foundation of how a gyroscope operates.

Modern electronic gyroscopes employ Micro-Electro-Mechanical Systems (MEMS) technology. A MEMS gyroscope typically consists of a microelectronic chip with an array of miniature capacitive plates or a small rotating mass. These components enable the device to detect rotational motion (Li et al., 2020, p. 4919). To detect rotational motion, the rotating mass of the gyroscope is connected to a reference or impact surface. During rotational motion, changes in the angular velocity of the rotating mass result in variations in the proximity of the capacitive plates. These changes are perceived as alterations in capacitance and are subsequently processed by electronic circuits.

In our A/D detection system work, the gyroscope is used to detect vehicles’ sharp turn motions and to calculate the magnitude of the turns. In acceleration and deceleration detection, parameters such as collision, no distortion, and bump cannot be detected with accelerometers. These undetectable parameters are detected with the gyroscope in the A/D detection system.

Microcontroller Unit (MCU)

Microcontroller Unit (MCU) is a specialized integrated circuit (IC) type responsible for the control and operation of electronic devices. Often referred to as a microcontroller or microcontroller unit, the MCU encompasses a central processing unit, memory units (including working memory and flash memory), input/output (I/O) ports, and an array of peripheral hardware components (HowStuffWorks, 2023). Microcontrollers are programmable by design and can be programmed by users to perform specific tasks. These programs are executed by the MCU's central processing unit. MCUs find widespread application in various electronic devices and systems, particularly in embedded systems, automotive control units, medical devices, and industrial automation systems. (, 2023). MCUs are renowned for their compact size, low power consumption, high processing capacity, and rapid response times. These characteristics make them an ideal choice for numerous applications that require energy efficiency, efficiency, and precise control. A/D detection system conducted utilizing the NXP S32K148 microcontroller platform. The NXP S32K148 is a 32-bit microcontroller operating on the ARM Cortex-M4 core, purpose-built for applications within the automotive industry. This microcontroller upholds the rigorous quality standards demanded by the automotive sector, ensuring dependable performance even in the demanding automotive electronics environment, and it adheres to the AEC-Q100 standards. Furthermore, it is fully compliant with the ISO 26262 functional safety requirements, rendering it a fitting choice for deployment in safety-critical systems (NXP, n.d.).

Controller Area Network (CAN)

The Controller Area Network (CAN-BUS) is a widely used communication protocol in various applications, particularly in automotive and industrial settings. It is a message-based protocol that enables different electronic control units (ECUs) within a system to communicate with one another efficiently (CAN in Automation (CiA), n). The fundamental principle behind the operation of the CAN-BUS protocol is to establish a reliable and robust means of data exchange.

CAN-BUS is based on the principles of message-oriented communication. It operates on a two-wire bus system, where one wire carries the high-level signal (dominant state), and the other carries the low-level signal (recessive state). In its working mechanism, CAN-BUS uses a differential signal pair, which provides noise immunity and reliability (Copper Hill Tech, n.d.). Each message transmitted on the CAN-BUS consists of an identifier, data, and a cyclic redundancy check (CRC) for error detection. ECUs on the network can both send and receive messages, and the protocol follows a priority-based arbitration system to handle concurrent message transmissions (Kvaser, 2023).

The CAN-BUS protocol is designed to be highly resilient and fault-tolerant. It employs a bit-wise arbitration process, allowing the node with the highest-priority message to gain access to the bus. This feature ensures that critical messages can be transmitted without interruption, making it ideal for real-time systems (Kvaser, 2023). In this study, messages containing vehicle speed and rpm data were read from the vehicle's CAN-BUS line.

Method

Acceleration deceleration detection system was developed to measure acceleration, deceleration, and sharp turn behaviors by harnessing data from a 3-axis accelerometer, gyroscope, and the vehicle's CAN-BUS messages. A block diagram illustrating the data sources and system output is presented in Figure 1.

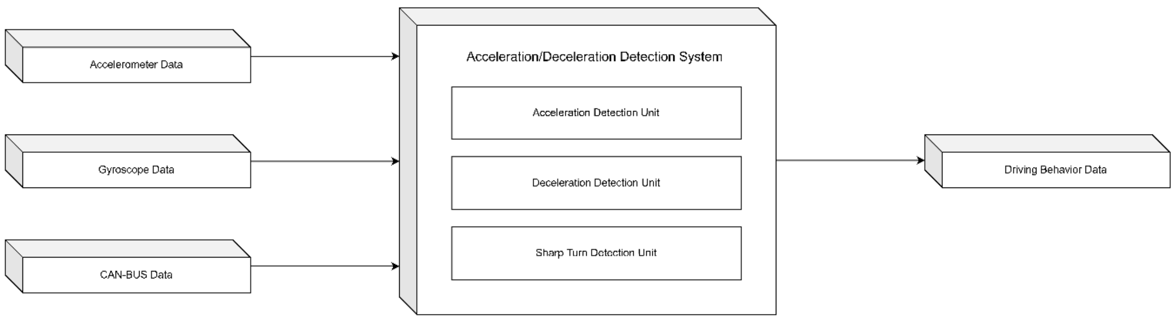

Figure 1. Acceleration deceleration detection system block diagram

The A/D detection system simultaneously detects acceleration, deceleration, and sharp turns. Each measurement is performed by independent software modules.

Acceleration Detection Software Unit

The accelerometer data, which includes the gravity component, should be processed in order to detect the vehicle's acceleration accurately. An acceleration detection software unit has been developed for this process. The raw data from the sensor represents the measured acceleration values along the X, Y, and Z axes. These values vary with the vehicle's motion and reflect the magnitude and direction of the detected motion as perceived by the accelerometer. However, directly summing up these values is insufficient for precise acceleration detection due to the inclusion of the gravity component. Hence, processing of the raw sensor data is required.

One of the processing steps involves calculating the magnitude of the acceleration values along the X, Y, and Z axes. The magnitude is computed by taking the square root of the sum of the squares of the three-dimensional acceleration values. This total value provides an accurate measure of the vehicle's acceleration magnitude by effectively eliminating the influence of the gravity component. Thus, the accelerometer data is filtered to focus solely on the components that indicate the vehicle's acceleration. Figure 2 illustrates the process for obtaining the acceleration magnitude representing the vehicle's acceleration.

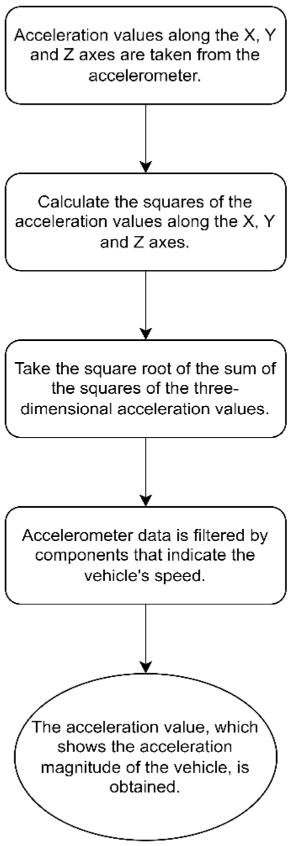

Figure 2. Vehicle acceleration magnitude calculation flow chart

It is necessary to apply filtering due to factors such as vehicle-induced motions and external influences like road inclination for the gyroscope. Undesirable noise and deviations may arise in the gyroscope data due to these factors. Therefore, processing steps are employed to enhance the accuracy of the gyroscope data and mitigate the unwanted effects.

The raw data from the gyroscope typically represent values for the three axes (X, Y, and Z) each. These values reflect the detected rotational velocity and direction. The values for all three axes are calculated from the raw data obtained from the sensor, yielding calibration data. The system ensures precision, resolution, and accuracy by collecting and processing idle state data from the vehicle. These values are utilized as offset values in the calibration settings of the sensors for subsequent measurements. Offset adjustment ensures the accuracy of the sensor readings. In the context of this automotive system, crucial vehicular data, encompassing vehicle speed and Revolutions Per Minute (RPM), is meticulously gleaned from the CAN-BUS. This entails the extraction of raw data messages from the vehicle's onboard diagnostics system. Subsequently, an intricate parsing process is initiated to extract and isolate the precise values for vehicle speed and RPM.

The parsed data, encapsulating the vehicle speed and RPM, is subsequently subjected to a sophisticated comparative analysis alongside meticulously filtered acceleration data. This specific acceleration data is diligently obtained through a suite of advanced sensors, including accelerometers and gyroscopes, designed to detect and quantify changes in the vehicle's acceleration profile. The fundamental aim of this intricate comparison is to elevate the precision of acceleration detection within the system. By cross-referencing the acquired speed and RPM values with the carefully filtered accelerometer and gyroscope data, the system can discern and discriminate real-world accelerative events from other driving factors.

This approach enhances the accuracy and reliability of the system's acceleration detection capabilities, contributing to a more nuanced understanding of the vehicle's dynamic behavior. Various factors such as road conditions, braking, and acceleration, turning motions, vibrations, and shocks cause changes in the accelerometer and gyroscope data during vehicle motion. To accurately interpret these changes and detect acceleration, additional control mechanisms are implemented as described in this section. When the vehicle experiences acceleration, the accelerometer readings exhibit positive values. To ensure the reliability of this acceleration data, a threshold check is performed to determine if the accelerometer value exceeds a system-defined threshold. It's important to note that when the vehicle undergoes a turning motion, the accelerometer values also experience changes. Therefore, to specifically detect situations without turning motion, it is expected that the gyroscope value remains below the defined threshold.

In the event that these conditions are not met, the accelerometer value is reset, and the vehicle returns to an idle state. Subsequently, all calculations and checks are restarted to confirm the presence of acceleration. Once acceleration is verified, data related to speed, time, and location is collected for transmission to the server. This process ensures the accuracy of the acceleration detection mechanism while accounting for variations caused by turning motions.

The accelerometer value is continually monitored to detect if it surpasses a predefined threshold, serving as an indicator of the vehicle's acceleration. Once this check is successfully completed, the speed measured at that moment is considered the initial speed. Subsequently, at 3-second intervals, the initial speed is updated by comparing it with the current speed. The difference between the initial and current speeds is used to determine the magnitude of acceleration.

If this difference exceeds the predefined threshold, it indicates that the vehicle is undergoing continuous acceleration. In such a scenario, the current speed becomes the new instantaneous speed, and the comparative process continues. On the other hand, if the difference between the new instantaneous speed and the initial speed remains below the threshold, it suggests that the acceleration phase has concluded. Throughout this meticulous process, essential parameters are established, including the acceleration rate, initial speed, final speed, and the duration of the acceleration phase. These critical data points are subsequently communicated to the server for further analysis and utilization. This method ensures precise tracking of acceleration dynamics while accommodating potential fluctuations in the vehicle's speed. The inputs and outputs of the acceleration detection unit are depicted in Figure 3. The flowchart of the algorithm for acceleration detection is represented in Figure 4.

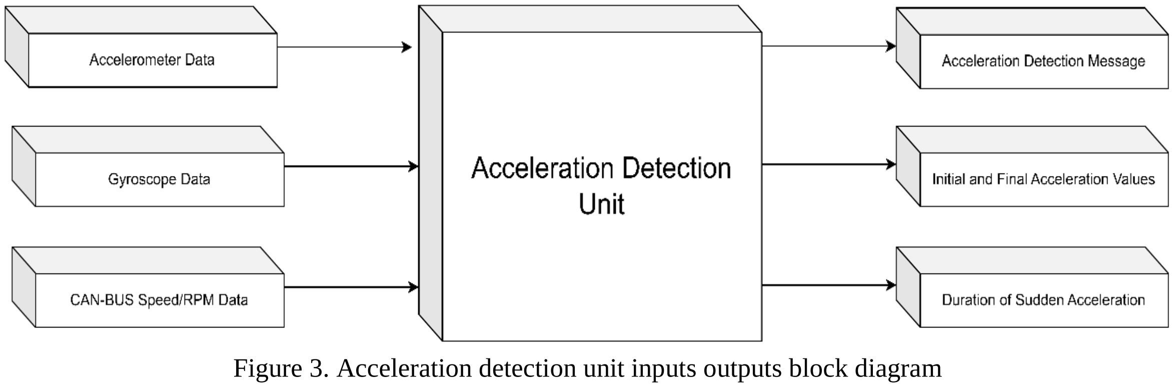

Figure 3. Acceleration detection unit inputs outputs block diagram

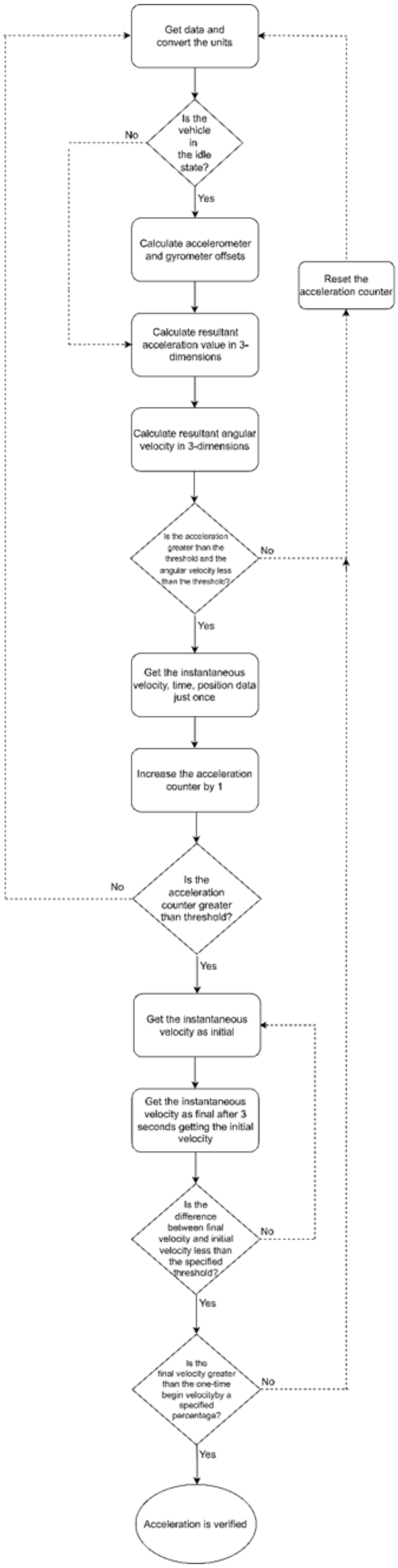

Figure 4. Acceleration detection algorithm flow chart

Deceleration Detection Software Unit

This algorithm was implemented in the developed deceleration detection software unit. As the first step of the deceleration detection algorithm, acceleration data in 3 axes (x, y, z) are taken from the accelerometer. The accelerometer returns a raw acceleration value. The following conversion process is performed in order to make sense of the raw data received. The raw data is converted into a meaningful acceleration value with the transformation.

$$R * \frac{F}{2^N} \quad (1)$$

Equation (1) shows the conversion from the raw sensor value to the acceleration value in mg. Where R represents the raw data read from the accelerometer, F is the range of the accelerometer module which is selected ±8 g in our study, and N refers the bit number which equals to 16. In the A/D detection system, the gyroscope is used together with the accelerometer for deceleration detection. Angular rotation data, which is raw data, in 3 axes (x, y, z) is read from the gyroscope. Dividing by resolution is used when converting this data into meaningful data as seen in (2).

$$\frac{R}{T} \quad (2)$$

Where R represent the raw data read from the gyroscope, and T is the resolution of the gyroscope module which equals to 14285 in our study. It is checked whether the vehicle is in motion by inserting it into the control cases determined by the acceleration and angular rotation data obtained from the accelerometer and gyroscope. If the vehicle is not in motion, the offset values of the accelerometer and gyroscope are set. If the vehicle is in motion other than idle, the acceleration values obtained are calculated in 3-dimension with the vector calculation as seen in (3). At the same time, angular rotation values taken from the gyroscope are calculated in 3-dimension, as well as the acceleration value calculated in the 3-dimension.

$$\sqrt{(x_{acc} - x_{off})^2 + (y_{acc} - y_{off})^2 + (z_{acc} - z_{off})^2} \quad (3)$$

The acceleration and angular rotation values calculated in 3-dimension are compared with the determined threshold values. If the value of the calculated data is less than the threshold values, instantaneous speed, time, and location data are taken. After the data is received, the counter holding the number of samples taken is increased to check that the slowdown is not instantaneous. These processes are repeated periodically to obtain the true deceleration value. The number of samples should be kept in a counter to filter the slowdown due to environmental factors such as bumps, ramps, and pits. It is checked whether the deceleration counter is greater than the specified threshold value. If this condition is met, the speed data is read from the CAN-BUS line of the vehicle and instantaneous speed data is obtained. In this way, the system is supported by CAN messages. After the instantaneous speed is read from the CAN line, the instantaneous speed is read again at the end of the specified time. A more stable deceleration is detected with the implementation of this process.

Finally, it is checked whether the final speed is less than the initial speed by the specified rate and percentage to ensure that the deceleration is stable. If the ratio is not less, the whole process repeats. Deceleration is only confirmed if the rate is slightly less than the initial speed at the final speed. With this last step, stable and real slowdown data are obtained. The inputs and outputs of the deceleration detection unit are depicted in Figure 5. The flowchart of the algorithm for deceleration detection is represented Figure 6.

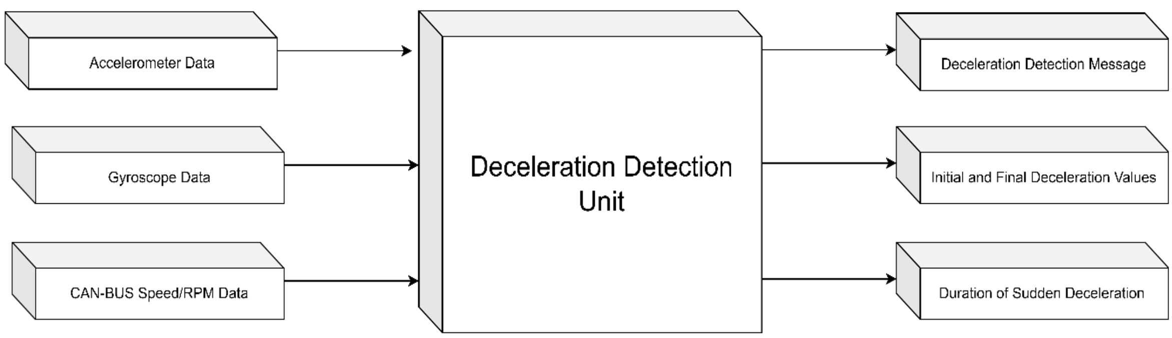

Figure 5. Deceleration detection unit inputs outputs block diagram

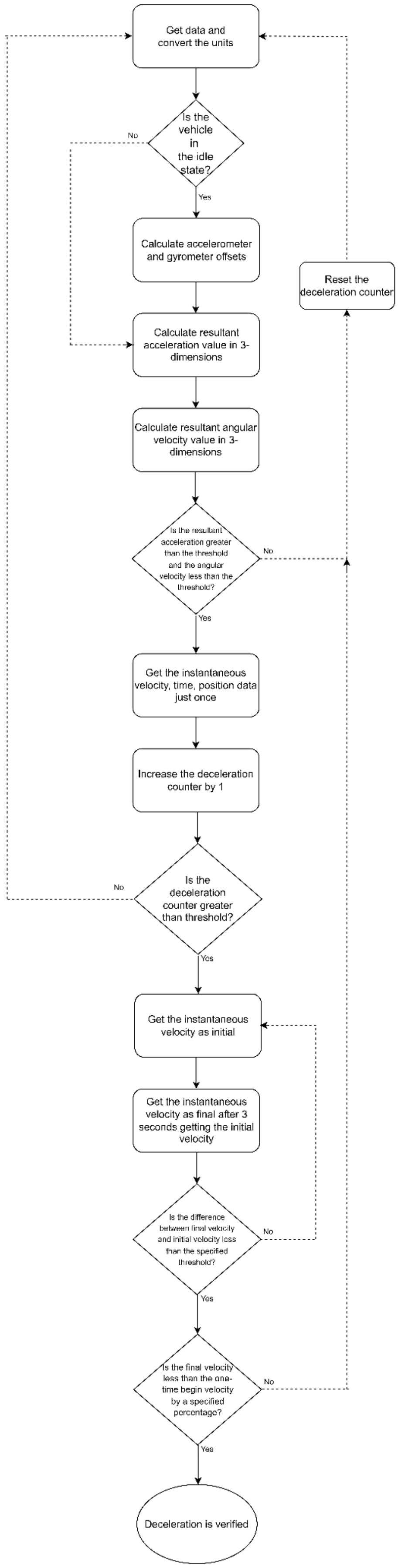

Figure 6. Deceleration detection algorithm flow chart

Sharp Turn Detection Software Unit

This algorithm was implemented in the developed sharp turn detection software unit. As the first step of the sharp turn detection algorithm, angular velocity data in 3 axes (x, y, z) are taken from the gyroscope. The gyroscope returns a raw angular velocity value. The following conversion process is performed to make sense of the raw data received. The raw data is converted into a meaningful angular velocity value with the transformation. In the A/D detection system, the accelerometer is not used for sharp turn detection. Angular velocity data in 3 axes (x, y, z) is enough for this operation. It is checked whether the vehicle is in motion by inserting it into the control cases determined by the angular velocity data obtained from the gyroscope. If the vehicle is not in motion, the offset values of the gyroscope are set. If the vehicle is in motion and not in an idle state, the values obtained from the gyroscope are calculated in 3-dimension with the addition of angular velocities in all dimensions. Thus, the resultant angular velocity is calculated. This resultant value is obtained for comparison with predetermined high and low threshold values. Crossing a high threshold indicates that the vehicle is in a sharp turn. The resultant angular velocity values below the low threshold value mean that there is no sharp turn or the sharp turn process has just terminated.

The A/D detection system expects this resultant angular velocity value to be higher than the high threshold value in the sharp turn algorithm. It calculates the angular velocity magnitude in degree per second (dps) when it first detects this situation and increments the rotation counter by one. Then, it waits for new data to be read from the gyroscope. After reading a value above the high threshold value the first time, the system waits for the resultant angular velocity value to be high 9 more times in a row, which corresponds to about half a second. If at least 10 consecutive values do not exceed the high threshold value, it determines that this process is not a sharp turn, resets the counters, and the angular velocity magnitudes it calculates. On the other hand, if the A/D detection system reads a higher value 10 or more times in a row, it now waits for a value less than the low threshold value to be read, which indicates that the sharp turn is starting to be completed, other higher data to come will not affect any situation until that lower value is read. In this case, it is certain that the vehicle has made a sharp turn, but it waits for the turn to be completed before sending information about the sharp turn to the server.

When the low value indicating that the sharp turn process has started to be completed for the first time comes, the counter that counts this stable state is increased by one and new data is awaited. Just like the high threshold value, this low value is expected to come 10 times in a row, confirming that the turning operation is definitely over. In this case, the sharp turn is confirmed and the process is completely reset. While waiting for 10 consecutive values, if a value above the threshold value comes, the counter controlling this lower threshold value is reset, because this shows that there is still a sharp turn. The inputs and outputs of the sharp turn detection unit are depicted in Figure 7. The flowchart of the algorithm for sharp turn detection is represented Figure 8.

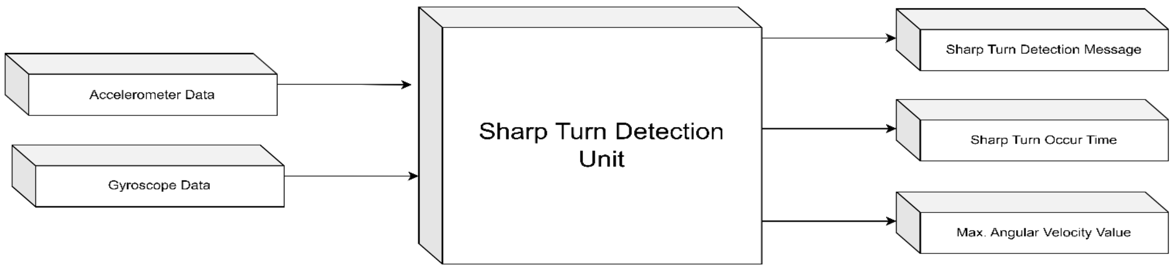

Figure 7. Sharp turn detection unit inputs outputs block diagram

Results and Discussion

Most traffic accidents are primarily attributed to poor driving habits. Monitoring drivers' abnormal driving behaviors online can significantly contribute to the reduction of traffic accidents. In an effort to enhance the accuracy and robustness of driving behavior recognition, algorithms based on Soft Thresholding and Temporal Convolutional Networks (S-TCN) have been developed (Zhao et al., 2022). Traffic accidents predominantly result from drivers' unsafe driving behaviors during their journeys. Studies aimed at addressing low safety issues through real-time driver alerts are underway. Research endeavors have combined Pose Estimation to identify various driving behaviors during the driving process and have concurrently developed a scoring model to assess drivers' driving behaviors (Dai et al., 2022).

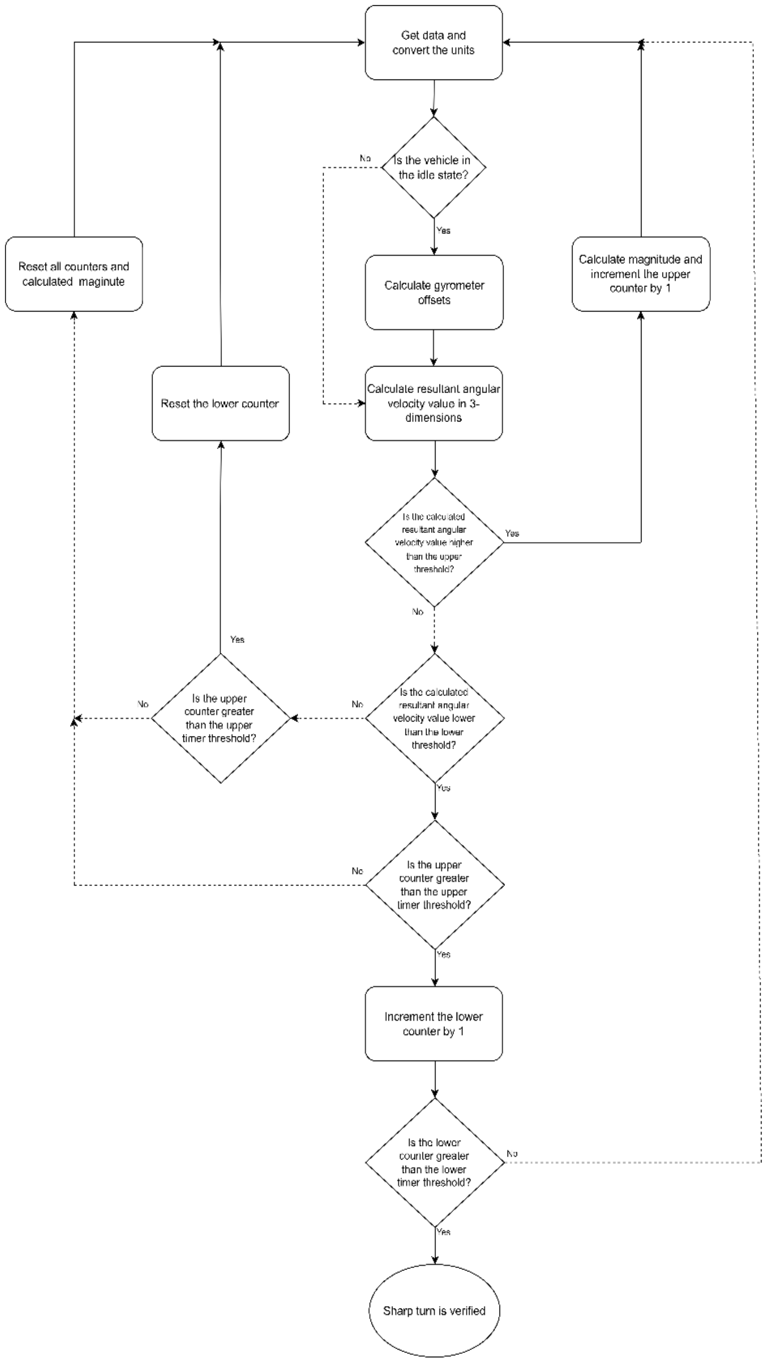

Figure 4. Sharp turn detection algorithm flow chart

The importance of driving data for the development of Advanced Driver Assistance Systems (ADAS) and the enhancement of traffic safety is increasing. Many predictive models may overlook the potential heterogeneity in driving behavior by not taking into account individual driver characteristics. A Finite Mixture of Hidden Markov Model (MHMM) is employed to segment driving behavior into different semantic segments. Approaches based on driving behavior analysis and machine learning methods are being developed (Zou et al., 2022). Our system for detecting driving behaviors, in comparison to existing systems, stands out in terms of ease of application and integration in this field. To characterize driving behaviors, this system was brought to life by employing the tools outlined in the materials section and applying the methods specified in the methods section. As a result, it has become possible to identify sudden acceleration, abrupt deceleration, and sharp turning movements in vehicles. These detections contribute to the acquisition of driving behavior data that can be meaningfully interpreted. The intention is to share this data with entities such as automotive companies, insurance firms, production planning, and vehicle service providers, with the aim of enhancing driving efficiency. The potential benefits arising from the utilization of this data are listed below.

Benefits for Insurance Companies

Driving behavior data is a valuable asset for insurance companies as it enables precise risk assessment for vehicle owners. These data are collected through sensors and telematics devices, capturing driving patterns, including sudden acceleration, abrupt deceleration, and sharp turning movements. By analyzing the output of the A/D detection system and making it interpretable, insurance companies can establish exact risk profiles for each policyholder. This affords the opportunity for a more detailed and equitable pricing structure; safer and lower-risk drivers are rewarded with lower premiums, while high-risk drivers incur higher premiums. This approach aims to optimize the profitability of insurance companies by aligning premiums with actual risk, reducing adverse selection, and enhancing the overall sustainability of the insurance industry. Furthermore, it seeks to encourage customers to adopt safe driving practices by providing opportunities for premium savings.

Benefits for Spare Parts and Aftermarket Services

Driving behavior data plays a pivotal role in gaining a better understanding of the maintenance needs of vehicles. Service providers can predict when specific components, including brakes, tires, and engine parts, should be replaced by monitoring wear and tear patterns. This predictive maintenance approach ensures cost-effective and efficient maintenance. Vehicle owners benefit from having a longer-lasting and more reliable vehicle, as maintenance is based on actual usage and wear, rather than traditional fixed schedules. Furthermore, this data can be leveraged to optimize spare parts inventory management and improve the aftermarket service supply chain. Manufacturers and service providers can ensure they have the correct parts available when needed, reducing unexpected maintenance costs and downtime for vehicle owners.

Benefits for Production Planning

Driving behavior data provides automotive manufacturers with the profound ability to understand how vehicles are used and the conditions under which they operate. This information can significantly influence production planning and processes. By aligning production processes with the real-world usage and wear patterns of vehicles, manufacturers can enhance the durability and reliability of their products. Moreover, this data can be utilized for more precise demand forecasting, leading to more efficient production planning. As a result, manufacturers can reduce overproduction, minimize inventory carrying costs, and respond more effectively to fluctuations in market demand. This not only enhances operational efficiency but also improves the sustainability and profitability of manufacturing operations.

Benefits for Vehicle Services

Driving behavior data enables automotive service technicians to proactively predict vehicle service requirements. By analyzing the output of the A/D detection system and making it interpretable, technicians can identify how specific faults and maintenance needs can be determined before they escalate into critical issues. This proactive approach reduces vehicle downtime and results in faster and more efficient servicing. Customers experience less inconvenience due to quicker turnaround times for repairs and maintenance, leading to increased customer satisfaction. Furthermore, vehicle service providers can optimize their service schedules, allocate resources more effectively, and reduce operational costs, ultimately enhancing profitability and competitiveness in the market.

Benefits for Efficient Driving Experience

Driving behavior data offers feedback to drivers to provide a more efficient driving experience. Drivers can reduce fuel consumption by improving their acceleration and braking habits, thereby reducing fuel costs and minimizing environmental impact.

Benefits for Production Strategy

Manufacturers can utilize driving behavior data to make strategic decisions for vehicle design and production. By comprehending how vehicles are used in real-world conditions, they can devise strategies to make their products more efficient and durable. This data-driven approach enables manufacturers to enhance their competitive advantage, surpassing customer expectations in terms of reliability, fuel efficiency, and overall performance. As a result, manufacturers can stimulate innovation by capitalizing on the insights provided by driving behavior data, continuously improving their products.

Accelerometer was used for acceleration and deceleration detections. At the same time, the A/D detection system, which is designed in real time, calculates by considering all environmental factors that the vehicle may encounter while on the road. A gyroscope is also included in the project for filtering false data in acceleration, deceleration, and sharp turn detection. The raw values read from the accelerometer and gyroscope were converted into real acceleration and angular rotation units and evaluated within the framework of the mathematical model. In addition to these, the A/D detection system is open to development both in terms of content and technique. In this system, which is expected to increase efficiency and control by sharing the obtained data with insurance companies, new features can be added by examining the data that can be obtained with the accelerometer and gyroscope in the light of different subjects. One of these features is the accident status of the vehicle, which will also be of interest to insurance companies. With the sudden change in both acceleration and angular rotation angle, serious vibration or accident in the vehicle can be detected and the user or related companies can be informed about the subject if necessary.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in EPSTEM journal belongs to the authors.

Acknowledgements or Notes

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