포스터 발표

차선 인지 기반 UKF 멀티 센서 로컬라이제이션

김민기* · 성윤모* · 이재풍**

Lane Detection-Based UKF Multi-Sensor Localization

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Key Words : Lane-aided localization(차선보조 로컬라이제이션), Sensor fusion(센서 융합), Unscented kalman filter (무향 칼만 필터), Inertial measurement unit(관성측정장치), Wheel odometry(휠 오도메트리)

ABSTRACT

This paper presents a practical lane-aided localization approach that fuses GPS, an inertial measurement unit (IMU), wheel encoder odometry, and a fast lane detector (UFLD v1). The camera image is undistorted and converted to a simple bird's-eye view so that lane points are measured in meters near the vehicle. From these points we compute two intuitive observations: the lateral offset from the lane center and the heading difference between the vehicle and the lane. An Unscented Kalman Filter (UKF) combines these lane observations with short-term motion from IMU and wheel encoders, while GPS provides global position when available. The result is a stable and real-time localization output that reduces lateral drift and heading error when GPS is weak (e.g., tunnels or tree shade). The system runs on ROS and can be integrated into lane-centric autonomous driving stacks with minimal effort.

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등가강성 기반 R-MDPS 모델링 및 전차량 시뮬레이션 적용

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Equivalent-Stiffness Modeling of Rack-Driven EPS (R-MDPS) and Full-Vehicle Simulation

Seunghan Kim*, Jayil Jeong**

Key Words : Electric Power Steering(전동식 조향장치), Equivalent-Stiffness(등가강성), Adams Full-Vehicle Simulation (Adams 전차량 시뮬레이션), Ball Screw reducer(볼스크류 감속기).

ABSTRACT

propose an equivalent-stiffness steering model for rack-driven electric power steering (R-MDPS) that reproduces full-vehicle behavior at reduced computational cost. In the ball screw, contact at the ball-race interface and the axial, bending, and torsional compliances of the nut and screw are evaluated static structural analyses to obtain stiffness, preload and friction. these are then mapped to a spring-damper representation. we construct the steering subsystem in MSC Adams with joint-level constraints that reflect the physical relationship between the rack and the motor, the housing while applying external loads that the real vehicle imposes on the rack (lateral forces transmitted from the front tires through the tie-rods and steering-input-induced torques). Embedding this equivalent model in a full vehicle assembly, we predict responses under combined maneuvers while explicitly accounting for rack force. The result is a modeling that preserves the key force transmission characteristics of R-MDPS enables low resource simulation for design and calibration work.

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자동차 엔진제어기 하우징 유 · 무에 따른 열적 특성 평가

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Thermal Characteristics Evaluation of Automotive Engine Control Unit with and without Housing

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Key Words : Engine Control Units(엔진제어기), Micom(마이컴), Thermal Damage(열손상), Driving Safety(주행안전성), Sudden Unintended Acceleration(의도하지 않은 가속)

ABSTRACT

This study investigates the behavior and driving safety of automotive Engine Control Units (ECUs) under thermal damage conditions. Thermal input was applied directly to the Micom location, starting at room temperature and increasing to 90 °C, then in 20 °C increments up to a maximum of 220 °C. When the housing cover remained in place, the surface temperature of the housing stabilized at approximately 160 °C, and the Micom temperature was maintained at about 60 °C, indicating normal ECU operation. However, when the housing cover was removed, the Micom surface temperature rose to approximately 220 °C, resulting in engine shutdown. Post-experiment X-ray imaging of the Micom revealed no structural abnormalities. It was concluded that when the Micom surface temperature exceeds 220 °C, damage to the internal conductor circuitry prevents normal ECU function. However, regardless of whether the housing was present or not, no sudden speed changes, malfunctions, or abnormal behaviors such as unintended gear shifting were observed before the engine stopped. The engine torque also remained within the normal range during brake operation. Under driving conditions, both the air flow and the air–fuel ratio remained close to 1, indicating stable and normal operation. These findings provide foundational data for understanding sudden unintended acceleration and abnormal automotive behavior induced by thermal input to the ECU.

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스마트 시티 환경 엣지 기반 차량 운행 안전 모니터링 단말기 설계 및 구현

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Design and Implementation of an Edge-Based Vehicular Safety Monitoring Device for Smart City Environments

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Key Words : Smart City(스마트시티), Edge Computing(엣지 컴퓨팅), Risky Driving Behavior(위험운전행동), Road Anomaly Detection(도로이상감지), Traffic Management(교통관리), FMS(차량관제시스템)

ABSTRACT

In recent years, the frequency of traffic accidents has shown a significant upward trend due to multiple converging factors such as risky driving behaviors, drowsy driving, driver distraction, and the presence of abnormal road conditions including potholes and surface irregularities. This study aims to reduce accident rates and protect human lives by designing and implementing an edge-based in-vehicle terminal that enables real-time monitoring of both driver behavior and road conditions within the context of smart city integration. The proposed device integrates three essential functional modules. First, eleven categories of risky driving behaviors such as rapid acceleration, sudden braking, and abrupt lane changes are analyzed in real time using vehicle speed and heading data. Second, an accelerometer sensor is employed to detect abnormal road conditions, including potholes, cracks, and uneven surfaces, thereby providing critical information for road infrastructure management. Third, the driver state is analyzed through a Driver Monitoring System. All detected events, along with contextual information such as event type, occurrence time, vehicle information, and location, are transmitted to a Fleet Management System via LTE communication. By edge computing, improving vehicle safety monitoring efficiency. The research shows that the proposed edge-based device can serve many stakeholders in a smart city. Transportation authorities can utilize the collected data for road maintenance planning, governments can formulate driver safety-related policies, and fleet operators can optimize vehicle operation management. Ultimately, this device contributes to the establishment of a safer and more sustainable transportation infrastructure, offering a practical solution to the rising challenges posed by hazardous driving behavior and deteriorating road environments.

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Design of an Anomaly Detection and Automatic Fire Notification System for Removable Battery Packs in Personal Mobility

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Key Words : Personal Mobility(개인형 이동수단), Removable Battery Pack(탈착식 배터리), Thermal Runaway(열폭주), Automatic Fire Notification(자동소방신고), SMS(문자메시지)

ABSTRACT

The rapid expansion of personal mobility such as electric scooters and e-bikes has introduced significant safety challenges, particularly regarding the use of removable battery packs during household charging and storage. Lithium-ion secondary batteries, widely adopted in these devices, are prone to risks such as thermal runaway, gas emission, and overheating, which may lead to fire accidents. With the number of such incidents steadily increasing, early detection of battery anomalies and rapid notification to emergency services are essential. The purpose of this study is to present a design proposal for a compact system that performs anomaly detection and provides automatic fire notification for removable battery packs in personal mobility. The proposed system integrates three key sensors—gas, heat, and temperature—to continuously monitor abnormal battery conditions. Data collected from these sensors are processed by an embedded processor, which executes real-time detection algorithms to identify hazardous states, including excessive heating, abnormal gas release, and sudden temperature fluctuations. Upon detecting such anomalies, the system triggers a local alarm and transmits an automatic fire notification directly to fire departments via LTE or Bluetooth module. The expected outcome of this design is a practical and effective safety measure that significantly enhances fire prevention and emergency response for personal mobility battery packs. By minimizing the time delay between anomaly detection and fire notification, the system has the potential to reduce casualties, protect valuable property, and increase user trust in battery-powered personal mobility.

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저마찰 구간에서 자율주행 화물차의 미끄러짐 방지를 위한 안전 속도 산정 방법

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Determination of Safe Driving Speed for Preventing Skidding of Autonomous Heavy Trucks on Low-Friction Roads

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Key Words : Heavy vehicle(화물차), Skidding(미끄러짐), Safe speed(안전 속도), Low friction(저마찰 노면), Simulation (시뮬레이션)

ABSTRACT

Heavy vehicles are highly susceptible to skidding accidents on curved roads, particularly under low-friction conditions such as icy or snowy surfaces. This study presents a method to determine the safe driving speed of heavy vehicles on horizontal curves by analytically modeling the relationship among vehicle speed, road curvature, and tire–road friction. The proposed approach constrains both longitudinal and lateral tire forces within the available friction limit to prevent skidding. TruckSim–MATLAB co-simulations were conducted under low pavement friction coefficients, demonstrating that the proposed speed profile enables stable cornering without vehicle skidding while maintaining sufficient braking distance before curve entry. The results provide a practical basis for enhancing the safety of autonomous heavy vehicles operating on low-friction curved roads.

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AI 기반 자율주행 시스템의 엣지 케이스 차량 인지 한계 분석 및 안전성 개선 방안 연구

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Edge-Case Vehicle Perception Limitations and Safety Improvement Study in AI-Based Autonomous Driving Systems

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Key Words : Autonomous Driving(자율주행), Edge-Case(엣지 케이스), Vehicle Perception(차량 인지), Fine-tuning (파인튜닝), Recognition Accuracy(인식 정확도)

ABSTRACT

The object recognition capability of autonomous driving systems has advanced considerably with AI-based models. However, the reliable detection of atypical vehicles—such as damaged cars or those with open trunks—remains a critical safety challenge. These edge cases deviate from standard appearances and often cause perception failures, posing serious risks in real-world scenarios. This study quantitatively analyzes the limitations of current perception models in recognizing such edge cases and proposes a data augmentation strategy to address them. A YOLO-based model was employed as the baseline to evaluate detection performance and identify weaknesses. To overcome data scarcity and enhance diversity, a synthetic dataset of atypical vehicles was generated using a vehicle simulation environment, incorporating variations in damage, trunk opening, and lighting conditions. The combined use of synthetic and real-world data was applied to fine-tune the baseline model. Experimental results demonstrate that synthetic data augmentation effectively mitigates perception failures. These findings underscore the importance of including edge-case data in training to ensure the reliability and safety of autonomous driving systems.

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차량 내 저주파 자기장 인체 노출량 평가 연구

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Evaluation of Low-Frequency Magnetic Field Human Exposure in Vehicles

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Key Words : Electromagnetic field exposure(전자파 인체노출), KS C 3380 standard(KS C 3380 표준), Low-frequency magnetic field(저주파 자기장), Human safety assessment(인체 안전성 평가), Vehicle interior measurement (차량 내부 측정)

ABSTRACT

Recently, concerns over the safety of human exposure to electromagnetic fields (EMF) have significantly increased worldwide. In response, Korea legislated human protection standards for electromagnetic fields through Article 47-2 of the Radio Waves Act in 2002. These standards regulate limits on specific absorption rate (SAR), electric field strength, and magnetic field strength, maintaining levels comparable to guidelines recommended by the International Commission on Non-Ionizing Radiation Protection (ICNIRP).

In this study, the domestic standard KS C 3380 was applied to evaluate low-frequency magnetic field exposure inside vehicles, targeting both internal combustion engine vehicles and electric vehicles. EMF exposure characteristics were comparatively analyzed according to measurement locations and vehicle operational conditions, including constant-speed driving and stationary states. The results are intended to serve as foundational data for the establishment of future EMF safety standards and policy development.

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건설기계 전기전자 분야 관리체계 개선에 관한 연구

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A Study on the Improvement of the Management System in the Electrical and Electronic Sector of Construction Machinery

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Key Words : Construction Machinery(건설기계), Safety(안전), Standard(표준), Electric(전기), Electronic(전자)

ABSTRACT

The construction industry continues to experience a high incidence of accidents, and with the recent enactment of the Serious Accidents Punishment Act, companies have increasingly promoted the development of advanced safety devices by integrating IT technologies with various sensors and control systems. As a result, the application of electrical and electronic components in construction machinery has expanded significantly. In Korea, the Construction Machinery Management Act provides the institutional framework for the regulation and promotion of the construction machinery industry. The purpose of this study is to support the advancement of the Rules on Safety Standards for Construction Machinery by reviewing the electrical and electronic provisions within its common clauses, along with applicable domestic and international standards, in order to identify and propose quantifiable elements. The findings of this study are expected to serve as a critical reference for future policy development, particularly when further validated through in-depth research and expert evaluation at the national level.

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A Multi-Vehicle Based System for Automated Detection and Reporting of Illegal Parking

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Key Words : Autonomous driving(자율주행), Object detect(객체 인지), Perception performance evaluation(인지 성능 평가), Sensor fusion(센서 융합), Deep learning(딥러닝)

ABSTRACT

Illegal parking is a persistent urban issue that undermines road safety and traffic efficiency. Conventional enforcement methods, such as patrol vehicles and fixed CCTV systems, are constrained by limited coverage and high labor costs. To address these limitations, this paper proposes a system that leverages multiple route vehicles, such as buses, equipped with license plate recognition and GPS modules to automatically detect and report illegally parked vehicles. During normal operation, each vehicle continuously records surrounding license plates along with their GPS coordinates, and the collected data are transmitted to a central server. The server aggregates and analyzes duplicate detections from multiple vehicles, determining illegal parking only when the same license plate is repeatedly observed at the same location by different vehicles, thereby minimizing false positives. The proposed system offers three major advantages: (1) enhanced reliability through multi-vehicle cross-validation, (2) wide-area coverage without the need for dedicated patrols or fixed infrastructure, and (3) efficient centralized management through server-based aggregation and analysis. By integrating existing public transportation fleets with intelligent enforcement technologies, this approach enables automated, reliable, and scalable illegal parking management.

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인체 모델의 주요 신체 부위별 생체충실도 평가

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Evaluation of the Biofidelity of a Human Body Model for Key Body Regions

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Key Words : Human body model(인체모델), Biofidelity(생체충실도), Finite element(유한요소), Thorax(흉부), Spine (척추), Neck(경부)

ABSTRACT

The advancement of autonomous driving technology has enabled diverse in-vehicle seating arrangements, raising the need for occupant safety evaluation in novel configurations such as rear-facing seats. Although Post-Mortem Human Subject (PMHS) experiments provide fundamental insights, the limited number of available tests limits the amount of data that can be collected. Finite element human body models (HBMs) have emerged as an effective alternative; however, previous studies have identified limitations in the biofidelity of HBMs in replicating the complex kinematics of rear-facing occupants. Therefore, to enhance the reliability of simulations, a systematic biofidelity validation of key body regions—the thorax, spine, and neck—is required.

In this study, the biofidelity of the HBM was evaluated and improved by comparing simulation outcomes with PMHS experimental data associated with injury mechanisms in each body region. Specifically, the thorax was validated by comparing chest deflection against PMHS data under four loading conditions: single belt, double belts, distributed belt, and hub impact. The spine was evaluated through dynamic analyses of six loading modes at the L3–L4 level and eight loading modes at the T12–L5 level, focusing on moment–angle and force–displacement responses. For the neck, rear-impact (4G) conditions were analyzed with emphasis on head angle variations and comparison to experimental corridors. The findings of this study provide a fundamental basis for enhancing the predictive accuracy and reliability of HBM simulations under diverse crash environments.

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ISO26262 차량 기능안전 – 계층적 안전 컨셉

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ISO26262 Automotive Functional Safety - Layered Safety Concept

Ilnam Park*

Key Words : Functional safety(기능안전), Safety concept(안전컨셉), Safety architecture(안전 아키텍처)

ABSTRACT

The complexity of automotive electronic control systems increases the likelihood of diverse faults at the controller level. ISO 26262 requires establishing a vehicle-level safety concept to achieve safety goals (SGs), but this often remains abstract and does not clarify how it can be implemented at ECU or SoC level. To address this gap, controller-level safety concepts must present a static safety architecture, defined as a set of elements and their interactions to fulfill safety requirements. However, conventional block diagrams, which merely include safety mechanism blocks alongside functional ones, are limited in showing which faults in lower-level functional blocks can actually be detected by specific mechanisms.

This paper proposes a Layered Safety Architecture that separates the Intended Function Layer and the Safety Mechanism Layer. The intended function layer includes ECU functions such as signal acquisition, torque calculation, and actuator control. The safety mechanism layer covers monitoring functions such as sensor plausibility checks, watchdogs, and fallback strategies. By mapping faults in functional blocks to their detectability by monitoring mechanisms, the approach makes explicit which faults are covered and which remain uncovered.

The methodology is illustrated using the E-gas concept. In this example, throttle control functions are monitored by redundant sensors, plausibility checks, and actuator feedback monitoring. The layered representation clearly demonstrates the relationship between fault sources and their detectability by safety mechanisms.

The proposed approach provides a systematic way to communicate controller-level safety concepts beyond conventional block diagrams. It highlights the strengths and limitations of monitoring mechanisms and offers a reference framework for designing and evaluating safety concepts in compliance with ISO 26262.

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EV 컨버전 1톤 트럭의 배터리 연결 프레임 단면 형상에 따른 구조해석 연구

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Structural Analysis Study on the Cross-Sectional Shape of the Battery Connection Frame of a 1-Ton EV Conversion Truck

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Key Words : Vehicle safety(자동차 안전), Electric vehicle(전기 자동차), EV conversion(전기자동차 변환), Structural analysis(구조해석)

ABSTRACT

According to the Life Cycle Assessment (LCA) of automobiles, eco-friendly vehicles produce significantly lower greenhouse gas emissions during operation, while internal combustion engine vehicles (ICEVs) have relatively low carbon emissions during manufacturing. Based on these environmental benefits, various studies are being conducted on EV conversions, which convert existing ICEVs to electric vehicles without scrapping them. This study aims to design a frame specifically designed for ICEs to prevent fatigue deformation and breakage at the connection point where a heavy battery is mounted. The target vehicle model was a compact 1-ton truck, a common type of truck in Korea, which is easier to convert than passenger vehicles. The actual vehicle frame was 3D scanned and reverse-engineered to create a 3D model using Fusion 360. Previous studies have used simple, easy-to-install L-shaped brackets for experiments. Analysis results have shown that the brackets are prone to deformation during long-term operation, and impacts can cause welds to break, potentially damaging the main frame. Accordingly, this study designed a subframe mounting method that minimizes damage to the main frame and is easy to replace, and measured and compared the structural safety according to the cross-sectional shape of the subframe pipe to suggest the optimal cross-sectional shape.

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MORAI 시뮬레이터를 활용한 자율주행 교통사고 재현 및 차량 거동 분석 연구

송치원* · 홍 준** · 백세룡*** · 이기범****

Autonomous Vehicle Traffic Accidents Reconstruction and Vehicle Behavior Analysis Using the MORAI Simulator

Chiwon Song*, Jun Hong**, Seryong Baek***, Kibeom Lee****

Key Words : MORAI Simulator(모라이 시뮬레이터), Traffic Accident(교통사고), Accident Recontruction(사고 재현)

ABSTRACT

With the increasing adoption of autonomous vehicles, accidents caused by interactions with human drivers have also been on the rise. Consequently, the need for systematic analysis of traffic accidents involving autonomous vehicles has become more critical. Such accident simulations require higher levels of realism and accuracy than ordinary autonomous driving simulations, and the precise reconstruction of vehicle behavior during accident scenarios is a key requirement. In this study, scenarios corresponding to SAE Level 3–4 conditions were defined to reproduce traffic accident cases of autonomous vehicles. These scenarios were implemented using the MORAI autonomous vehicle simulator, through which the consistency of vehicle behavior in autonomous driving accident situations and the validity of simulation-based accident reconstruction were verified.

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마찰 특성의 벤치마킹 분석을 통한 복합재 브레이크의 제동 성능 고찰

심재훈* · 황세라* · 심형식* · 김성신* · 유 강** · 김성완*** · 이성주**** · 신재호*****

A Study on Braking Performance of Composite Brake through Benchmarking Analysis of Friction Characteristics

Jaehun Shim*, Sera Hwang*, Hyungshik Shim*, Sungshin Kim*, Kang Yoo**, Sungwan Kim***, Sungjoo Lee****, Jaeho Shin*****

Key Words : Composite Brake Disc(복합재 브레이크 디스크), SiC(탄화 규소), Friction Characteristic(마찰 특성), Cu Free Friction Material(구리 배제 마찰재), Friction Material(마찰재)

ABSTRACT

Carbon ceramic composite brake is widely applied in high-end vehicles of many car manufacturers and we have also developed our unique carbon ceramic composite brake to compete with our competitors for a long time. Although carbon ceramic composite disc has excellent mechanical properties such as thermal and wear properties, we found it weakness generating cracks between friction layer and loading layer under salt water environment. So, we improve this weakness for the new carbon ceramic composite disc. In this paper, we suggest the new fiction material for the new carbon ceramic composite disc. To do this, we set up the criteria of friction characteristics through benchmarking. Sequentially, a variety of tests such as stability of friction coefficient, braking temperature rise are conducted to confirm its friction characteristics. In addition, we consider regulation of heavy metal in the friction material and development direction setup to response it. Finally, we hope that this study is used to principal research for the new carbon ceramic composite brake.

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고속 정면 충돌 환경에서 후향좌석 탑승자 보호를 위한 에어백 영향 평가 및 HBM 거동 비교

안용진* · 정대창** · 정가람** · 이동길** · 김성래*** · 김태웅*

Assessment of Airbag Effects and Human Body Model Responses for Rear-Facing Seat Occupants in High-Speed Frontal Collisions

Yong-Jin An*, Dae-Chang Jung**, Ga-Ram Jeong**, Dong-Gil Lee**, Sung-Rae Kim***, Tae-Wung Kim*

Key Words : Rear-facing seat(뒤보기 시트), Post-mortem human subjects(사후 인간 피험자), Human body model(인체 모델), Finite element(유한요소), Head injury criterion(머리 상해치), Rib fracture(갈비뼈 골절)

ABSTRACT

With the advancement of autonomous driving technology, seating arrangements are diversifying, and front seats may rotate 180 degrees to face the rear in future vehicles. Such configurations increase the risk of severe injuries during high-speed frontal collisions, as confirmed by recent Post Mortem Human Subject (PMHS) tests, underscoring the need for new restraint systems. Since no crash test dummies currently replicate human kinematics in this scenario, Human Body Models (HBMs) have emerged as a viable alternative.

This study evaluates the protective effects of airbag deployment and compares the responses of two HBMs: the Global Human Body Models Consortium (GHBMC) and the Total Human Model for Safety (THUMS). A simulation environment was developed using manufacturer-provided seat and cockpit models, and sled pulses identical to physical tests were applied. Results showed that airbag deployment significantly reduced head and thoracic injuries in both models.

In conclusion, this work quantifies airbag protection and highlights behavioral differences between HBMs, providing a basis for future crash safety assessments under diverse seating configurations.

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자동차 주행 중 발생하는 BSR 진단 프로세스에 관한 연구

유종구* · 이원철** · 손성배*** · 손선익****

A Study on the BSR Diagnostic Process Occurring During Automotive Operation

Jonggoo Yoo*, Wonchul Lee**, Sungbae Son***, Suneik Son****

Key Words : Noise observe(노이즈 옵저버), BRS(버즈, 스퀵, 래틀), Assembly Tolerance(조립 공차), Abnormal Noise (이상 소음), Automotive Quality(자동차품질)

ABSTRACT

This study quantitatively analyzes Buzz, Squeak, and Rattle (BSR) noises occurring during automotive operation and proposes methods for diagnosis and repair to enhance automotive safety and comfort. Drivers typically perceive automotive abnormalities through auditory and visual cues, with warning lights and sounds controlled by an integrated system of sensors, controllers, and actuators. However, BSR noises originate from mechanical interactions such as friction and gaps between suspension components, exhaust systems, doors, and body panels, often serving as early indicators of potential automotive defects. In this research, a automotive exhibiting a rattle noise during inertial driving (from 60 km/h to 30 km/h at 1,300 rpm) was examined. Utilizing Noise Observer technology, the noise source was localized to the first exhaust muffler bellows. Structural investigations revealed assembly tolerances that caused differential gaps between the hanger bracket and the automotive body (7 mm on the left side and 3 mm on the right), correlating with noise generation on the left. By inserting shims to reduce the larger gap, both audible noise and abnormal vibration signals measured by the Noise Observer were effectively eliminated. This demonstrates that even minor structural variations can induce mechanical stress and vibrations contributing to BSR noise. Additionally, analysis of engine assembly deviations highlighted how manufacturing tolerances affect noise generation. The findings emphasize the importance of combining advanced measurement tools with deep learning-based diagnostic algorithms for accurate noise source identification. Such integration enables timely maintenance, reduces misdiagnoses, and improves overall automotive quality. This study provides practical methodologies for manufacturers to address BSR noise challenges in modern automotive system, where tighter component clearances and higher performance demands increase susceptibility to such issues.

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NVIDIA Omniverse 기반 디지털 트윈 시뮬레이션을 활용한 가상 주행 데이터 검증 연구

이은지* · 우태걸* · 이수천* · 이세훈* · 정세연** · 권희재** · 박강문***

Validation of Virtual Driving Data Using a Digital Twin Simulation Based on NVIDIA Omniverse

Eunji-Lee*, TaeGeol Woo*, Su-cheon Lee*, Sehun Lee*, Hee Jae Kwon*, Jungse Yeon*, Kang-moon Park***

Key Words : Digital Twin(디지털 트윈), Nvidia Omniverse(엔비디아 옴니버스), Simultation Data(시뮬레이션 데이터), Automotive Driving Data(자동차 주행 데이터)

ABSTRACT

Acquiring edge cases and rare driving scenarios, such as aggressive or abnormal driving, in real-world data collection is limited by cost and time constraints. Moreover, intentionally generating such rare situations in real-world environments is practically challenging. In order to overcome these limitations, research is increasing to generate simulation data constructed through a digital twin environment. However, for the generated virtual data to be effective, the results extracted from the simulation environment must closely resemble real-world observations, necessitating a systematic validation framework. In this study, we construct a simulation environment identical to the real-world setting based on measured data using NVIDIA Omniverse. This study aims to verify the practical utility of the omnibus virtual data through comparative analysis with actual data. To verify this, a simulation is executed in the same environment, and quantitative comparison is performed on the extracted driving data through time series consistency of the actual vehicle data, the reconstruction error, etc. Through this quantitative comparison, it can be demonstrated that the omnibus virtual data can sufficiently simulate the actual data. As a result, the existing real-vehicle data and omnibus output data show very high similarity, which can reduce costs and free driving environment configuration, and support the effectiveness of using driving data generated by digital twins as an alternative to real-vehicle.

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차량 경량화 및 안전성 향상을 위한 TPMS 구조 소재의 충격 특성 시뮬레이션 연구

임세준* · 정석환** · 임성한***

A Study on the Simulation of Impact Characteristics of TPMS Structural Materials for Vehicle Lightweighting and Safety Improvement

SeJun Im*, SeokHwan Jung**, Sung-Han Rhim***

Key Words : Triply periodic minimal surface(삼중 주기 최소 표면), Lightweight design(경량 설계), Energy absorption (에너지 흡수), Finite element analysis(유한요소해석)

ABSTRACT

현대 자동차 산업에서 차체 경량화와 충돌 안전성 확보는 상충되는 핵심 설계 과제이다. 이에 대한 해결책으로, 높은 비강도와 에너지 흡수 효율을 지닌 삼중 주기 최소 표면(Triply periodic minimal surface, TPMS) 구조를 구현한 소재의 차량 부품 적용 가능성이 주목받고 있다. 그러나 이러한 TPMS 기반 구조의 기하학적 매개변수와 충격 성능 간의 관계에 대한 정량적 데이터는 아직 부족하다.

본 연구는 슈바르츠 다이아몬드(Schwarz Diamond) TPMS 구조를 기반으로, 차량용 충격 흡수 부품(범퍼 빔, 에너지 흡수재, 크래시 박스 등)의 경량 설계를 위해 설계 변수에 따른 낙하 충격 응답을 정량적으로 분석하였다. 단위 셀 크기(10-20 mm), 회전 각도(0°-45°), 상대 밀도(50%-80%)를 조합한 48개 조건을 설정하였다. ABS(Acrylonitrile Butadiene Styrene) 시편을 이용한 낙하 실험을 통해 유한요소 시뮬레이션 모델을 검증하였으며, 시뮬레이션 결과와 비교 시 오차는 6% 미만이었다. 이후 모든 조건은 50J 충격 하에서 시뮬레이션을 통해 분석하였고, 충격 흡수 성능은 크레이터 깊이로 평가하였다.

분석 결과, 크레이터 깊이는 상대 밀도 증가에 따라 선형적으로 감소했으며, 셀 크기와 회전 각도는 비선형적 반응을 보였다. 최적 조건에서는 0.49 mm, 최악 조건에서는 2.47 mm의 깊이를 나타냈으며, 회귀모델(R^2=0.93)을 통해 성능 예측도 가능함을 확인하였다. 이는 향후 TPMS 구조를 활용한 차량 부품의 초기 설계 단계에서 고려할 수 있는 유용한 참고 자료가 될 수 있다.

이 논문은 2025년도 정부(산업통상자원부)의 재원으로 한국산업기술진흥원의 지원을 받아 수행된 연구임(RS-2023-KI002686, 2025년 산업혁신인재성장지원사업)

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임베디드 에지 디바이스 기반 다종 센서 통합 아키텍처 설계 및 구현

임재원* · 문성철* · 김인수** · 박재홍***

Design and Implementation of an Embedded Edge Device-Based Multi-Sensor Fusion Architecture

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Key Words : Embedded edge computing(임베디드 에지 컴퓨팅), Low-latency data path(저지연 데이터 경로), On-board sensor networking(온보드 센서 네트워킹)

ABSTRACT

In field edge environments for autonomous driving or industrial safety, perception results from cameras, LiDAR, and radar must be fused with low latency and high reliability; however, limited compute/memory budgets and both data copies and UDP non-determinism undermine real-time performance. We design and implement a unified data path comprising a zero-copy camera pipeline, a shared-memory–based inter-process data exchange layer, and a single SPI fusion/egress endpoint to simultaneously reduce copy overhead and latency variability. The proposed architecture integrates UDP-ingressed LiDAR/Radar detections and on-board vision processing within the same pipeline: a shared-memory–based inter-process data exchange layer that enables low-copy transfer, while the single SPI endpoint executes final fusion and deterministic output. Our prototype confirms the feasibility and functional correctness of the unified pipeline under edge constraints.

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컷아웃 상황에서 정지 보행자와 차량 표적에 따른 자율주행자동차의 반응 특성 차이 연구

조준성* · 정재일**

A Study on the Differences in Response Characteristics of Autonomous Vehicles to Stationary Pedestrian and Vehicle Targets in a Cut-Out Situation

Jun Seong Jo*, Jayil Jeong**

Key Words : Autonomous Vehicle(자율주행자동차), Cut-Out Scenario(컷아웃 시나리오), Stationary Pedestrian(정지 보행자)

ABSTRACT

Standard Euro NCAP safety protocols for autonomous systems primarily focus on vehicle-to-vehicle scenarios. This study investigated system responses to vulnerable road users by modifying the Euro NCAP 'Cut-Out' protocol, replacing the standard stationary vehicle target with a stationary pedestrian dummy. The differences in system reactions were quantitatively analyzed under identical dynamic conditions, focusing on the activation timing of Forward Collision Warning (FCW) and Autonomous Emergency Braking (AEB), deceleration initiation, and peak deceleration. The results revealed clear differences in system response. This suggests limitations in current sensor perception or decision logic for atypical stationary pedestrians and highlights the need to enhance system capabilities and test protocols to improve pedestrian safety.

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실험실 환경에서 차량 내부의 외부 오염물질 측정을 위한 CFD 기반 가스상 오염물질 분사 위치 최적화

최규권* · 유성식** · 하성용*** · 이흥식****

CFD-Based Gaseous Pollutant Injection Location Optimization for Measuring External Pollutants Inside a Vehicle in a Laboratory Environment

Kyu Kwon Choi*, Sungsik Yoo**, Sung Yong Ha***, Heung Sik Lee****

Key Words : CFD(전산 유체 해석), Wind Tunnel Test Chamber (풍동실험실), Exterior Pollutant Material(외부 오염물질), $k-\omega$ Turbulence Model($k-\omega$ 난류 모델), Case Study(사례 연구)

ABSTRACT

On-road driving is essential for evaluating the infiltration of external pollutants into vehicle cabins; however, quantitative comparisons are limited due to the difficulty of controlling environmental conditions. To overcome this limitation, laboratory experiments are conducted in which a blower reproduces driving airflow, and external pollutants are injected into the airflow within a controlled chamber. Since installing the injection device inevitably risks damage to the experimental equipment, selecting the optimal injection location is crucial. In this study, the flow behavior of NO_2 was analyzed using computational fluid dynamics (CFD) considering various injection locations inside the blower. NO_2 was injected at arbitrary positions while the blower rotor operated at a constant speed for 10 seconds. The NO_2 mass fraction was measured at designated points on the bonnet, and four injection locations were compared and analyzed for both SUV and sedan vehicles. The results indicated that Case-4 produced the highest NO_2 mass fraction for the SUV, whereas Case-1 yielded the highest value for the sedan. When the average results across both vehicle types were considered, Case-4 exhibited the highest concentration, suggesting that it represents the optimal injection location for pollutant introduction within the blower.

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PC-Crash 상해 정도 분석 결과를 적용한 자동차 기능 안전 위험 상황 심각도 설정 방법론

최영준* · 천동준**

Methodology for Determining Hazard Severity in Functional Safety Using PC-Crash Injury Analysis

Youngjun Choi*, Dongjoon Chun**

Key Words : Hazard analysis and risk assessment(위험 요소 분석 및 위험 평가), Functional safety(기능 안전), Abbreviated injury scale(미국의 약식 상해 등급), Safety integrity level(안전 무결성 등급), Pc-crash(피씨 크래시), Severity(심각도)

ABSTRACT

The modern automotive development industry is rapidly transitioning from traditional mechanical component-based designs to Electrical/Electronic (E/E) system-oriented architectures, bringing increased attention to safety issues arising from E/E system malfunctions. The international standard ISO 26262 regulates the determination of the Automotive Safety Integrity Level through Hazard Analysis and Risk Assessment using three parameters: Severity, Exposure, and Controllability. However, Severity is currently assessed mainly from a qualitative perspective, limiting its ability to quantitatively reflect actual accident risks. This study proposes a quantitative assessment method for Severity by employing the widely used accident analysis software PC-Crash to simulate vehicle–pedestrian collisions and applying the Abbreviated Injury Scale to the simulation results. The proposed approach enables the derivation and integration of safety requirements into E/E system design and development, providing a more realistic basis for functional safety integrity management in the automotive domain.

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횡방향 안정성 향상을 위한 능동 현가장치 제어 전략 연구

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Active Suspension Control Strategies for Improving Lateral Stability

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Key Words : Active suspension(능동 현가장치), Stability(안정성), Lateral(횡방향), Tilting control(기울임 제어)

ABSTRACT

Modern vehicle suspension systems have evolved from conventional passive damper and coil spring configurations to semi-active systems and air spring technologies. Recently, active suspension systems have begun to be selectively applied to premium vehicles. Conventional active suspension strategies have primarily focused on controlling roll and pitch motions to enhance ride comfort.

In this study, a tilting control strategy is proposed and experimentally validated as an alternative to conventional roll suppression approaches. Tilting control refers to a method that intentionally inclines the vehicle body toward the inside of the corner during turning maneuvers. This strategy effectively reduces the lateral acceleration perceived by the driver, minimizes vertical load transfer between the inner and outer sides of the vehicle, and improves tire grip, thereby offering a distinct advantage over traditional roll suppression control.

To evaluate the effectiveness of the proposed control strategy, a ramp steering maneuver was conducted. The results show that the vehicle equipped with the tilting control exhibited superior performance in terms of yaw rate and lateral acceleration compared to both a conventional vehicle and a vehicle with suppressed roll motion control. This indicates that the tilting control strategy enhances the lateral limit performance and overall lateral stability of the vehicle during cornering.

These findings demonstrate that the proposed tilting control strategy can more effectively improve lateral stability compared to conventional roll suppression control. Furthermore, the results suggest that this approach has strong potential to improve vehicle stability under extreme driving conditions, such as high-speed cornering and rapid lane changes, particularly for future electrified vehicles.

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e-Axle 시스템의 기능안전설계 및 안전목표에 관한 연구

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A Study on the Functional Safety Design and Safety Goals of the e-Axle System

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Key Words : Safety Goal(안전목표), Functional Safety Concept(기능적안전개념), e-Axle(전동액슬), Electric Vehicle (전기자동차), Traction Motor(구동모터)

ABSTRACT

본 논문은 e-Axle 시스템에 대한 위험원 분석 및 리스크 평가(HARA: Hazard Analysis and Risk Assessment)를 기반으로 안전목표(SG: Safety Goal) 및 기능적 요구사항(FSC: Functional Safety Concept)을 도출하고 이에 대한 연구를 수행하였다. 먼저 개발 대상인 e-Axle 시스템에 대해 기술적 조사 및 분석을 실시하였으며, 이를 바탕으로 잠재적인 위험요소를 식별하고 환경 조건을 고려한 리스크 분석을 통해 안전목표 및 기능적 요구사항을 정의하였다. 본 연구의 목적은 개발 중인 e-Axle 시스템을 적용한 차량의 전자전기 시스템(HW 및 SW)에 대한 기능 안전성을 확보하는 데 있다.

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카메라 센서 악의 상황에서 ADAS 성능 평가를 위한 VILS 환경 구축

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VILS Environment for Evaluating ADAS Performance in Adverse Camera Sensor Conditions

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Key Words : ADAS(첨단 운전자 보조 시스템), Adverse Sensor Condition(센서 악의 상황), Vehicle-in-the-Loop Simulation (차량 포함 루프 시뮬레이션),

ABSTRACT

Many functions of ADAS (Advanced Driver Assistance Systems) have become highly dependent on camera sensors. During driving, cameras may experience failures under various environmental conditions, and their performance can also degrade due to factors such as lens breakage or dust contamination. However, research on whether ADAS can operate safely under such adverse conditions remains limited. In this study, three major adverse scenarios-dust contamination, lens breakage, and camera failure-were defined, and a DCGAN-based model was designed to generate degraded images. An overlapping algorithm was developed to synthesize these generated images with video data. Through this algorithm, real-time images acquired from vehicle sensors can be transformed into representations reflecting faults, dust, or breakage. To evaluate ADAS performance when interacting with surrounding vehicles under such adverse sensor conditions, the proposed fault-image generation algorithm was applied to the sensor environment of the autonomous driving simulator (MORAI SIM), and a Vehicle-in-the-Loop Simulation (VILS) framework was constructed with an autonomous vehicle. This enables the analysis of performance for lane keeping, emergency braking, and emergency steering under adverse sensor conditions.

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초저상 스키드 조향 로봇의 경로 추종 향상을 위한 토크 최적화 알고리즘

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Torque Optimization Algorithm for Enhanced Path Following in Low-Profile Skid-Steering Robots

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Key Words : Skid-steering robot(스키드 스티어링 로봇), Torque distribution(토크 분배), Motor current allocation(모터 전류 할당)

ABSTRACT

This study fundamentally addresses the problem of target path following performance degradation resulting from hardware design uncertainties in low-profile 4WD skid-steering robot platforms. Conventional skid-steering control systems only distribute motor current into two groups thereby losing the opportunity for active compensation of individual driving wheel dynamic imbalances. This deficiency acts as a primary cause of critical path deviation and lateral instability, particularly in situations demanding high maneuverability. To overcome these limitations and ensure the robot's precision controllability, this paper proposes a 4-wheel individual torque optimization and distribution algorithm. The proposed algorithm is based on the robot's accurate dynamic model and comprehensively considers real-time path errors and vehicle dynamic states to calculate and assign the optimal Torque Vector required for each wheel. This approach effectively cancels out hardware uncertainty factors within the control domain, minimizes driving Slip, and thus secures the robot's lateral stability and path-following accuracy. The performance and robustness of the proposed control scheme were experimentally verified through complex driving scenarios, including S-curve path following and high-speed cut-in maneuvers.

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