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(10) Cut-Out Scenario Generation with Reasonability Foreseeable Parameter Range from Real Highway Dataset for Autonomous Vehicle Assessment

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(11) Investigating the Potential of a Scenario Catalogue for Automated Driving Safety Evaluation to Cover Real-World Crashes

Marko Medojevic, Hisashi Imanaga, Jacobo Antona-Makoshi, Maki Kawakoshi (JARI),
Hideaki Satoh (JAMA)
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アブストラクト

＜環境分野＞

(1) リーンバーン SI エンジンを搭載したシリーズハイブリッド車両への廃熱回収システム適用に関する研究

成毛 政貴, 北村 高明 (JARI)

　Recovering the waste heat is important to improve fuel efficiency of a hybrid electric vehicle. In this study, waste heat recovery systems such as organic Rankine cycles (ORC) and thermoelectric generators (TEG) were applied to a series hybrid electric vehicle with a lean burn SI engine that can be operated at an excess air ratio of 2.0. The effects of waste heat recovery systems on fuel economy were evaluated by using one-dimensional numerical simulation. The improvement of fuel economy using ORC and TEG was 2.67% and 1.14%, respectively. ORC was more effective in improving fuel economy than the TEG.

(2) 燃料組成が多気筒ガソリンエンジンの燃焼安定性に及ぼす影響

成毛 政貴, 伊藤 貴之 (JARI)

　The effects of fuel components on EGR and lean limits in multi-cylinder gasoline engines were investigated. The combustion stabilities for various fuel components varying the olefin contents and adding oxygenate components such as ethanol and ETBE were especially evaluated. The experimental results show that the fuel components have a significant impact for the EGR and lean limits. It was found that the fuel containing a large volume of olefin with ethanol could extend not only EGR and lean limit but also knock limit. We revealed the potentiality for improving thermal efficiency with adjusting fuel components.

(3) Experimental and Modeling Study for Lubricant Oil Consumption in Turbocharged Diesel Engine

Mayumi Matsuno, Masaki Naruke, Takaaki Kitamura (JARI)

　The friction loss in an internal combustion engine can be minimized by reducing the viscosity of the lubricant oil. However, when reducing the viscosity, if the light component of the lubricant oil increases, the lubricant oil consumption (LOC) increases; therefore, it is necessary to fully understand oil consumption behavior. In this study, the consumption behavior of lubricant oils was extensively investigated in both the steady and transient states. The results show that the LOC increases under transient conditions in contrast to the steady state. In addition, an oil evaporation model was constructed to calculate the transient lubricant oil evaporation (LOE) and LOEs of different lubricant oils by considering the oil composition. Both experimental and calculation results clarified that the increase in LOC under the transient state was caused by oil rising and that the main factor was oil transport, not LOE.

(4)　Impact of Active Material Ion Diffusion Coefficient on Overpotential in Lithium-Ion Batteries

Keisuke Ando (JARI),
Mai Tsuta, Kiyoshi Kanamua (Tokyo Metropolitan Univ.)

Simulating battery performance is crucial for effectively developing lithium-ion batteries (LIBs). However, ensuring the accuracy of the input parameters remains a significant challenge. Key parameters of active materials, including the exchange current density and ion diffusion coefficient, mutually affect each other, posing challenges for independent measurement. This study utilized single-particle measurements and battery performance simulations to evaluate the impact of the diffusion coefficient on the exchange current density in LiCoO2, the active material of LIBs. The findings revealed that diffusion coefficients below 10^{-8} cm2 s−1 influence the Tafel plot, representing the exchange current density. Fitting analysis of the LiCoO2 single-particle measurement by Simcenter Battery Design Studio (BDS) yielded an exchange current density of 6.6×10^{-4} A cm−2, a diffusion coefficient of 5.9×10^{-11} cm2 s−1, and a charge transfer coefficient of 0.55.

(5)　Iron Oxide and Hydroxide Speciation in Emissions of Brake Wear Particles from Different Friction Materials Using an X-ray Absorption Fine Structure

Hiroyuki Hagino (JARI),
Ayumi Iwata (Keio Univ.),
Tomoaki Okuda (Meteorological Research Inst. Japan Meteorological Agency)

Iron (Fe), the main component of non-exhaust particulates, is known to have variable health effects that depend on the chemical species of iron. This study characterized the possible contribution of iron oxides and hydroxides to airborne brake wear particles under realistic vehicle driving and braking conditions with different brake pad friction materials. We found significant differences in wear factors and PM10 and PM2.5 emissions between non-asbestos organic (NAO) and European performance (ECE) brake pads. Iron was the dominant contributor to PM10 and PM2.5 brake wear particles for both NAO and ECE. The iron concentration ratio in the particle mass (PM) was comparable to the disc-to-pads ratio measured by wear mass. The fact that magnetite, which is of interest with respect to health effects, was less abundant in NAO than in ECE suggested that tribo-oxidations occurred in NAO. Metallic iron is generated not only from abrasive wear but also from tribo-chemical reduction with magnetite as the starting material. We found that there were differences in PM emissions between brake friction materials, and that the phase transformations of iron differed between friction materials. These differences were apparent in the distribution of iron oxides and hydroxides. Heat, tribo-oxidation, and tribo-reduction are intricately involved in these reactions.

(6) Feasibility of Measuring Brake-Wear Particle Emissions from a Regenerative-Friction Brake Coordination System via Dynamometer Testing

Hiroyuki Hagino (JARI)

Emissions of brake-wear particles are commonly associated with vehicular traffic. We investigated the feasibility of quantifying brake-wear particle emissions under realistic vehicle driving and braking conditions with a currently used regenerative friction brake coordination system. We used a braking system installed in commercially available plug-in hybrid electric vehicles and found that it reduced emissions by 85% for PM10, 78% for PM2.5, and 87% for particle numbers (PNs) compared with the system installed in vehicles with internal combustion engines. Brake friction work showed a linear relationship with PM10 and PM2.5. Nanoparticle PM emissions tended to increase slightly with regenerative braking but did not contribute significantly to the overall PM percentage. The emission events of high concentrations of nuclei-mode particles (<20 nm in diameter) in electric vehicle brake assemblies designed for regenerative braking use under high-temperature, high-load braking conditions with full-friction brakes. The nuclei-mode particles amplified the PN emissions and led to high variability. In strict regulatory certification tests where measurement reproducibility and stability are required, it is appropriate to measure PNs under brake conditions appropriate for the actual use of electric vehicles rather than under full-friction brake conditions or to remove particle measurements smaller than 20 nm.

(7)　高齢ドライバを対象としたペダル踏み間違いに至る操作過程の分析

細川 崇，橋本 博（JARI），
平松 真知子，石田 肇（自工会）

The purpose of this study was to investigate the accidents caused by pedal missteps in the elderly. We applied the method of examining missteps by driving simulator in the previous report to the elderly. When the foot position was displaced during braking, the elderly failed to correct, and multiple cases of misstepping were confirmed. Additionally it was considered that it is not recommended for both elderly and non-elderly people to step on the floor with the heel attached to the floor because the lateral movement of the foot is insufficient when the heel is attached to the floor during braking.

(8)　頭部および脚部傷害レベル予測における深層学習手法の応用と予測結果の可視化

國富 将平，新井 勇司（JARI）

D-Call Net と称した先進事故自動通報システム（Advanced Automatic Collision Notification）の本格運用が 2018 年より開始され，同システムから提供される傷害予測情報を基に医師の現場派遣が行われている．しかしながら，同システムの傷害予測アルゴリズムは自動車前席乗員のみを予測するにとどまっている．そのため，歩行者を含む交通弱者への予測対象拡大と更なる傷害予測精度の向上が求められている．そこで，我々は深層学習手法を用いた画像認識による，歩行者頭部傷害予測モデルを提案してきた.

本研究では，これまでに構築した傷害予測モデルに脚部傷害を新しく予測対象に加えることで，成人男性歩行者モデルを対象とした頭部と脚部の傷害部位単位での傷害レベル予測を試みた．また傷害予測モデルの傷害予測性能は，適合率と再現率，F 値，正解率を用いて評価した．さらに，傷害予測モデルの判断根拠を考察するために，頭部傷害値（HIC＜1000, HIC≥1000）と脚部骨折情報（骨折あり，骨折なし）を組み合わせた 4 クラスを正しく予測した画像に対して SHapley Additive exPlanations（SHAP）を適用した．これにより予測結果に対する各特徴量（入力画像の各ピクセル）の寄与を求めることで，傷害予測時にモデルが着目する画像内の特徴を可視化した.

頭部及び脚部傷害レベル予測では，作成した傷害予測モデルの正解率は 88.2％であり，その高い傷害予測性能が確認された．しかしながら，HIC≥1000，且つ脚部骨折なしであるクラスの各評価指標値は低く，当該クラスのデータ数の不足が要因の一つとして挙げられた．一方，SHAP を用いた特徴量の可視化に関しては，歩行者モデルの立位姿勢時における頭部，自動車モデルとの衝突時の左右の肩の傾斜（車両と衝突した側の肩の位置が低くなる），肘をつく腕部の挙動及び腕部の跳ね上げや身体への巻き付きが各クラスを予測する際に寄与の高い特徴であることが示された.

本研究結果から，深層学習による画像認識と歩行者衝突画像を用いることで，歩行者の頭部傷害有無と脚部骨折有無の組合せから構成される傷害部位単位での傷害レベル予測の実現性が示唆された．また，傷害予測モデルは衝突時における歩行者モデルの頭部位置，左右の肩の傾斜，肘をつく腕部の挙動及び腕部の跳ね上げや身体への巻き付きの挙動に着目することで，予測を実施する可能性があることが確認された.

(9)　高齢ドライバの歩行能力向上によるペダル操作エラー低減効果

細川 崇, 田川 傑 (JARI),
平松 真知子, 前 博行 (自工会), 鈴木 康裕 (筑波大附属病院),
清水 如代, 羽田 康司, 國府田 正雄 (筑波大)

This study aimed to test the hypothesis derived from a previous report suggesting that improving walking ability can reduce the occurrence of foot position errors, such as stepping on the accelerator instead of the brake. We implemented a supervised walking ability improvement program in a group of 30 elderly participants and analyzed its effects. Over a 12-week period with at least three sessions per week, the training program significantly improved balance function and walking ability, leading to a significant reduction in foot position errors. Additionally, the study confirmed that the elderly responded positively to the program.

(10) Cut-Out Scenario Generation with Reasonability Foreseeable Parameter Range from Real Highway Dataset for Autonomous Vehicle Assessment

Husam Muslim, Shun Endo, Hisashi Imanaga, So Kitajima, Nobuyuki Uchida (JARI),
Eiichi Kitahara, Khoichiro Ozawa, Hideaki Sato (JAMA), Hiroki Nakamura (JARI)

This study aims to generate test cases for scenario-based assessment of automated driving systems (ADS) when encounter a cut-out maneuver where the lead vehicle having changed lanes, revealing a new lead vehicle that, in some cases, is slower than the original lead (the cutting-out) vehicle. We extracted the cut-out scenarios from an established real-world traffic dataset recorded by instrumented vehicles on Japanese highways and then defined them using vehicle kinematic parameters (velocities and distances). The extracted scenarios were analyzed based on the direct correlation between every two consecutive vehicles: a rear part that describes the correlation between the following vehicle and the cutting-out vehicle; and a frontal part that describes the correlation between the cutting-out vehicle and the preceding vehicle. Parameter ranges were quantified with a regression model and determined based on the risk acceptance threshold applied in the field of Japanese high-speed trains and annual exposure by professional highway drivers to produce a scenario space with a reasonably foreseeable range in which ADS may not produce crashes lest it performs worse than human drivers. A multi-dimensional distribution analytical approach was used to derive a correlation between the following and preceding vehicles considering the initial longitudinal velocities. Results suggest that when the time headway between the following vehicle and the cutting-out vehicle is equal to or more than 2 s, there should not have collision risks between the following vehicle and the preceding vehicle. These findings can help to understand normative driver behavior during cut-out scenarios and to generate accident-free scenario space for which ADS must perform flawlessly.

(11) Investigating the Potential of a Scenario Catalogue for Automated Driving Safety Evaluation
　　　to Cover Real-World Crashes

Marko Medojevic, Hisashi Imanaga, Jacobo Antona-Makoshi, Maki Kawakoshi (JARI),
Hideaki Satoh (JAMA)

　　Automated driving safety evaluation predominantly relies on scenario-based approaches. In this study, authors adopt a functional scenario catalogue initially conceived by JAMA to evaluate automated driving safety on limited access highways. The potential of this catalogue to cover real-world crashes was investigated by comparing each scenario in the catalogue with crash patterns from two international data sources: the NHTSA's pre-crash scenario typology for crash avoidance research report, and the 2020 IGLAD's codebook. The results indicate the potential of the scenario catalogue to comprehensively cover both the NHTSA and the IGLAD crash scenario typologies.

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