# 자동차 구조 제어

# 실차 성능 평가 시 타이어 내부 형상 변화 평가 방법에 관한 연구

임종욱* · 김종환* · 송무섭* · 송계주* · 김현준**

# A Study on the Method of Evaluating the Internal Shape Change of Tyre in Vehicle Performance Evaluation

Jongwook Lim*, Jonghwan Kim*, Musub Song*, Kyejoo Song*, Hyunjun Kim**

**Key Words :** Computer Vision(컴퓨터 비전), Change in tire interior geometry(타이어 내부 형상 변화)

ABSTRACT

The burgeoning growth of the electric vehicle (EV) market has presented new engineering challenges, particularly in the realm of tire performance and safety. This study focuses on the complexities of tire-to-ground contact, given the increased vehicle weight and the resultant energy interactions with the road surface. Utilizing a Image Sensor mounted on the Front Left (FL) wheel, we conducted tests at a constant speed of 30kph in a straight-line trajectory at the KATRI PG facility. This innovative approach aims to overcome the limitations of existing verification methods by providing a more flexible and efficient means of capturing dynamic tire-ground contact.

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# 소수와 안정성의 관계 연구

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# The Relationship Between Prime Number and Safety

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**Key Words :** Prime number(소수), Braking stability(제동안정성), Zeta function (제타함수)

## ABSTRACT

This study explores the intrinsic properties of Prime numbers and their relevance to ensuring optimal braking stability in safety-critical systems, such as the automotive and tyre industries. It investigates the linkage between Prime numbers and braking force analysis utilizing Zeta and Gamma functions. Additionally, I would like to ask a question about a mathematical problem. This is about regularity, which is the essential problem of Prime numbers. Of course, we cannot know the regularity of Prime numbers, but the general view is that they do not exist randomly. Therefore, we would like to propose a hypothesis using the distribution of Prime numbers.

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# 4륜 독립 조향/구동/제동 차량을 위한 타이어 마찰 특성을 고려한 연산 효율적 제어 분배 알고리즘

이태연* · 정용환**

# Efficient Control Allocation Algorithm for Four-Wheel Independent Steering/Drive/Braking Vehicles Considering Tire Friction Characteristics

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**Key Words :** Control allocation(제어 분배), Four-wheel independent steering(사륜독립조향), Four-wheel independent driving(4륜독립구동), Four-wheel independent braking(4륜독립제동), Pseudo-inverse(수도 인버스), Optimization(최적화)

## ABSTRACT

Recently, four-wheel independent steering/drive/braking vehicles, utilized in autonomous and electric vehicles, have emerged as the next-generation mobility solutions. With this rise, efficient control methodologies for these vehicles have become critical. However, implementing control allocation in such vehicles, considering the diverse dynamic characteristics and computational demands, presents a complex challenge. This research aims to address this challenge using the pseudo-inverse method. Specifically, we focus on extracting eight essential inputs - tire forces and steering angles - for each wheel from a linear matrix equation. We then compare the pseudo-inverse method with optimization techniques. The linear matrix formula is based on the Fixed Efficiency Matrix (FEM), a basic effective method employing the pseudo-inverse. By utilizing both the pseudo-inverse and MATLAB's fmincon function for optimization, the extraction performance of these crucial inputs is analyzed. Notably, despite similar performance outcomes between both methods under FEM, the pseudo-inverse method demonstrated computational advantages. Building on this computational advantage, we introduce the Dynamic Efficiency Matrix (DEM). Traditional FEM overlooks lateral yaw moments, limiting its ability to comprehensively consider longitudinal and lateral forces. DEM, designed to consider tire nonlinearities in real time, utilizes the friction ellipse fitting function and the tire Magic Formula. By accounting for both longitudinal and lateral forces, improved cornering performance was observed. The computational efficiency of the pseudo-inverse method combined with the performance merits of DEM provides a promising approach to control allocation in four-wheel independent steering/drive/braking vehicles, anticipating enhanced driving and path-tracking performance.

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# Yolov5 기반 눈길 타이어 트랙 학습 모델 및 칼만필터를 활용한 강건 차로 유지 알고리즘 개발

김동현* · 정용환**

# Development of a Robust Lane Keeping Algorithm Using YOLOv5-Based Snowy Tire Track Learning Model and Kalman Filter

DongHyun Kim*, Yonghwan Jeong**

**Key Words :** Autonomous driving(자율주행), Snowy road(눈길), Lane keeping(차로 유지), Tire track detection(타이어 트랙 인식), Deep learning(딥러닝), Kalman filter(칼만 필터)

## ABSTRACT

Autonomous driving is a technology that recognizes surrounding situations, determines movement, and controls the vehicle. Currently, the commercialization of autonomous driving technology is being delayed due to several factors. One of the many causes of delay is that there are situations where recognition is incomplete. In this study, we determine that tire tracks on snow can replace lanes in snowy situations where recognition is incomplete, and propose a lane maintenance algorithm using tire tracks. Since tire tracks have different shapes and colors depending on the amount of snow and the amount of surrounding light, snowfall images in various situations were used. Data was augmented by selecting images of different situations, such as the presence or absence of snow, situations by time zone, depth of tire tracks, and color differences in tire tracks due to exhaust fumes. When augmenting data, the dataset was acquired by augmenting the data to make it into data that could be acquired rather than artificial data, such as inversion, enlargement, rotation, and noise addition. The dataset created in this way was labeled with tire tracks using CVAT (Computer Vision Annotation Tool), and a learning model was obtained using Yolov5. The evaluation of the learning model used the Precision-Recall curve and validation dataset. Tire tracks are detected in the test image, and a bird's eye view image is obtained using back projection transformation. The center lines of the tire tracks are detected in the bird's eye view image, and the tire track is selected among the detected center lines. Based on the selected tire track, the center line, which is the driving direction of the vehicle, was derived, and the Kalman filter was applied to enable lane maintenance. It was confirmed that the proposed algorithm can maintain lanes in imperceptible snowfall situations.

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# 후륜 가변 지오메트리 서스펜션의 통합제어를 통한 성능 향상

한창희* · 김자유* · 이경수** · 박재용***

# Enhancing Performance Through Integrated Control of Rear Wheel Variable Geometry Suspension

Changhee Han*, Jayu Kim*, Kyongsu Yi**, Jaeyong Park***

**Key Words :** Variable geometry suspension (가변 지오메트리 서스펜션), Tire characterisitcs (타이어 특성), Camber and toe angles (캠버 각과 토우 각), Lateral force (횡방향 힘), Weighted Pseudo-inverse Control Allocation (의사역행렬 제어할당)

## ABSTRACT

This paper presents analysis on tire characteristics for rear wheel variable geometry suspension. The growing interest in variable geometry suspension systems of automotive arises from their proven ability to enhance vehicle handling and stability, which has encouraged the development of a variety of systems designed to control camber and toe angles. However, there is a lack of comprehensive research investigating the combined effects of these factors on lateral force utilization. In this study, tire data was analyzed to explore the potential for implementing precise control of camber and toe angle adjustments. Tire characteristics are measured using the MTS (Measure Test Simulate) flat-track test platform, and the Magic formula model is utilized for analysis. Reverse contour map, considering actuator limits, visualize possible camber angle and toe angle combinations within the operating range. Focusing on the WPCA-based control strategy, the optimal control plan for the camber angle and toe angle to optimize performance of lateral force distribution. The influence of camber angle and toe angle control on vehicle handling and stability is examined using MATLAB/Simulink. Results have shown that appropriate control of camber and toe angles can lead to improved performance.

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# 알루미늄 단조 휠 내구/강도 해석을 위한 물성 확보 및 표준 검토

장진희* · 허성필*

# A Study of Securing Material Properties of Aluminum Forging Wheel for Fatigue/Strength FEM Analysis and Examination of Standard

JinHee Jang*, SungPil Heo*

**Key Words :** Wheel(휠), Cornering Fatigue Test(굽힘 방향 피로 시험), Endurance(내구), Impact test(충격 시험), Dynamic stiffness(동강성), Finite Element Analysis(유한요소해석)

## ABSTRACT

In automobile parts, the proportion of Aluminum is increasing due to weight reduction and exterior design. Because Aluminum can be shaped through variety process such as Casting, Forging, Rolling and etc. HMC mainly applied Low pressure casting or Low pressure casting-Flow forming process in manufacturing aluminum wheel. but Forging wheel were applied in first for High performance vehicle as reduction weight compare with casting wheel. And in order to satisfy fatigue/strength ES specification, Finite element analysis is performed at design stage, However, because we didn't possessed mechanical properties of forging aluminum, and we couldn't that.

In this study, We executed durability test of wheel component and compared with FEA result using similar material properties, we secured fatigue properties without a lot of time and cost. And we got the strength properties from specimen test. Using these result, The first forging wheel were developed as satisfied engineering specification, prevented filed problems.

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