

Bangladeshi Road Condition–Aware Smart Suspension Tuning System

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Abstract

Road quality across Bangladesh varies drastically from smooth urban segments to severely degraded rural pathways, creating persistent challenges for vehicle stability, ride comfort, and long-term mechanical reliability. Most vehicles on these roads still rely on passive suspension systems that cannot respond to changing surface conditions, resulting in excessive vibration, component wear, and reduced driving comfort. This study introduces a practical and locally adaptable smart suspension tuning system specifically tailored to the diverse road environment of Bangladesh. The proposed system utilizes low-cost accelerometers and vibration sensors to continuously interpret road roughness. The collected data is processed through an adaptive control mechanism capable of adjusting suspension stiffness in real time. In parallel, a machine learning model is investigated to forecast upcoming surface irregularities from historical sensor patterns, allowing the system to prepare the suspension configuration before encountering rough terrain. A prototype unit was installed and evaluated on representative Bangladeshi road surfaces, including cracked asphalt, pothole-ridden segments, and unpaved stretches. The initial trials demonstrated a noticeable reduction in transmitted vibration levels and a clear improvement in ride comfort and vehicle stability. The findings indicate that an affordable and scalable suspension solution can be developed using readily available components, offering a bridge between advanced automotive technologies and the practical requirements of developing regions. Overall, this work emphasizes the importance of localized engineering innovations and highlights how context-specific automotive technologies can contribute to safer, smoother, and more durable vehicular operation in resource-constrained environments.

Keywords

Adaptive Suspension Control, Road Condition Classification, Vehicle Dynamics Optimization, Vibration Mitigation Techniques, Low-Cost Mechatronic Systems.

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Biographies

Akram Hossain is a 5th semester undergraduate student in the Bachelor of Science program in Automobile Engineering at the World University of Bangladesh. Alongside his academic coursework, he has remained actively involved in voluntary initiatives through the WUB Automobile Club and the AL-Falah Helpline of DPI. He holds a four-year Diploma in Automobile Engineering and has accumulated nearly five years of hands-on professional experience in the automotive field. He is presently employed at Transcom Distribution Company Limited, where he works with vehicle diagnostics and the development of aftermarket automotive solutions. His academic and professional interests include engine performance enhancement and advanced thermal management systems, particularly for refrigerated and cold-chain transport vehicles. He is currently contributing to several ongoing projects focused on improving temperature regulation mechanisms in cold-chain logistics operations across South Asia.

Md. Ashfaq Hossain Akand is currently pursuing a Bachelor of Science in Automobile Engineering at the World University of Bangladesh (5th semester). Prior to this, he completed a four-year Diploma in Engineering and has served in the automotive sector for nearly seventeen years. His professional experience includes diagnostics, thermal management systems, and the development of aftermarket automotive technologies. His research interests include exhaust emission reduction, engine performance optimization, thermo-fluid systems, and temperature regulation in refrigerated vehicles. He is actively engaged in several ongoing projects involving hybrid battery thermal behavior, cold-chain vehicle temperature management, and cost-effective retrofit solutions for emission improvement in older vehicles commonly used in South Asia.

Ataur Rahman is pursuing a Bachelor of Science in Automobile Engineering at the World University of Bangladesh and is currently in his 5th semester. He has remained actively involved in various automotive extracurricular activities, serving as a member of the WUB Automobile Club and previously as an Advisor to the UIST Automobile Club. He also serves as the Member Secretary of the Al-Falah Helpline of DPI. Professionally, he works as an Instructor in the Department of Automobile at the As-Sunnah Skill Development Institute. Alongside his academic responsibilities, he completed a three-month training program in PLC and Industrial Automation, gaining practical experience with industry-standard automation software and control systems. His academic interests include internal combustion (IC) engines, vehicle diagnostics, sustainable mobility solutions, practical motorcycle servicing and performance tuning. Driven by a strong passion for both theoretical knowledge and hands-on application, he aspires to contribute significantly to innovation, technical skill development, and research in the evolving automotive and automation industries.

Md Shafi Ullah is a 5th semester student in the Bachelor of Science in Automobile Engineering program at the World University of Bangladesh. He previously completed a Diploma in Engineering under the Power Department of Chittagong Polytechnic Institute and completed a six-month specialized course in Automobile Technology from BKTTC. He is currently employed as a Service Engineer at Abul Khair Group, where he is acquiring practical experience in automotive maintenance. His responsibilities include diagnosing technical issues, performing maintenance operations, and providing support for heavy industrial and automotive equipment. He is deeply motivated to apply engineering principles to real-world challenges and is committed to strengthening his expertise in service, repair, and industrial maintenance practices. He aims to build a strong professional career in the service and maintenance sector and contribute to the advancement of Bangladesh's industrial landscape through continuous learning and dedicated technical service.