ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)

Volume 11 Issue 7 July 2024

Fuzzy Gear Shifting Control Optimization to Improve Vehicle Performance, Fuel Consumption and Engine Emissions

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Abstract— This study uses a multi objective optimization to the fuzzy management of gear changing in a car with an automatic manual transmission (AMT) Adaptive-weight genetic algorithms were used to find the best fuzzy membership functions in accordance with the input and output ranges and the weighted optimal control criteria, withthe goal of enhancing acceleration performance and loweringengine fuel consumption and emissions The car is depicted acting in a certain way. using longitudinal dynamicssimulations developed using the Simulink and the ADVISORTM fuel converter, which calculates engine emissions and fuel consumption. These calculations were based on the FTP-75 emissions test procedure that examines how the engine performs momentarily in relation to the hot and cold stages of the operating cycle. When the ideal fuzzy control hits the best balance between the optimization parameters demonstrated a 19.72% fuel savings linked to hydrocarbons (12.90%), carbon monoxide (29.50%), and nitrogen oxides (17.02%). to a typical gear shifting operation for a vehicle, there is a reduction in emissions and an improvement in acceleration performance gearbox with manual control. Moreover, the optimized fuzzy gear shifting control significantly enhances the relationship between fuel consumption and emissions as comparison to another ideal AMT control that only takes speed constraints into account.

Index Terms— Blockchain, Electronic Health Record, Medical Hashing Control, Security and privacy of data.

I. INTRODUCTION

Urban traffic congestion is made worse by an increase in motor vehicles, and this is related to air pollution caused by car exhaust emissions. Furthermore, the majority of greenhouse gas emissions are caused by conventional gasoline engines Governments have implemented a number of measures to lower vehicle emissions in an effort to regulate this pollution The automotive industry is encouraged by these laws to create cars that are highly efficient, use less fuel, and emit fewer emissions Improved combustion engine operation control, alternative fuels, and powertrain layouts are examples of vehicle innovations that were developed to circumvent existing regulations.. Furthermore, as automated manual transmissions (AMTs) offer advantages over manual transmissions in terms of fuel efficiency, driving comfort, and shifting quality, new technologies for AMTs have been created This analysis of the powertrain's effects includes a multi-objective optimization of the vehicle's gearbox that accounts for gearboxes with four, five, and six speeds. Nitrogen oxide (NOx) emissions are reduced by 6.75% and fuel consumption is reduced by 7.5% as a result of this modification. also tracks the vehicle's emissions using GPS data., allowing for the defining of the engine regime after the majority of tailpipe emissions are produced when the engine is cold. The gear shifting strategy establishes whether a shift is required and which gear to employ at any given time based on the powertrain design Additionally, changing the engine's operating point (output torque and speed) has an impact on pollutants, fuel consumption, and heat created by the engine. The gearbox ratio between the engine and the car's traction wheels is changed to achieve this. The engine power available at the selected operation point and the transmission ratio that places a restriction on the available output torque at the traction wheels will also affect the vehicle's performance depending on the gear ratio chosen. As a result, the shift strategy might take into account a number of factors to determine which gear is best: Three different dynamic shift schedules: one-parameter (speed), two-parameter (speed and throttle opening), and three-parameter (acceleration, speed, and throttle opening) For the same car and driving pattern An optimization technique to improve vehicle performance, emissions, and fuel consumption as a function of gear change methods was developed in a previous study and is investigated in this paper. The speed limits at which a gear shift might happen were revealed by the paper results. Through the analysis of the optimization solutions, it was discovered that the speed limits (gear shifting strategies) that produce the fewest emissions cause the engine to run faster than the manufacturer's recommended speed because the engine must warm up more quickly during the cold start phase. boosting the effectiveness of the catalyst. But this behaviour Fuel usage rises when the upshift is delayed because Even during the hot start and stabilized periods of the engine cycle, the suggested gear shifting method maintains the same engine regime. Thus, taking into account the

ISSN (Online) 2394-2320
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Volume 11 Issue 7 July 2024

optimization of fuzzy logic control, this paper concentrates on improving the AMT system's gear shifting control. According to the paper fuzzy controllers are the state-of-the-art for managing intricate automotive systems with a low fuel and pollution target while preserving or enhancing performance. The properties of the fuzzy controller are the reason for it. Fuzzy controllers are effective in managing uncertain data, including noise in the acquisition system and models that are either non_existent or poorly specified. The fuzzy controller can be utilized in a multi-input multi-output (MIMO) system, which is the second justification for using the state system. Because a vehicle's condition has a significant impact on how it is controlled, the fuzzy controller can be utilized to execute the optimal gear changes because it is adjustable based on a variety of boundary criteria. The fuzzy controller's use to MIMO systems makes it possible for several input factors such vehicle speed, engine temperature, and needed while generating torque and acceleration. Apart from that, the

A genetic algorithm can also optimize parameters, claims the author of a unique fuzzy set optimization method. put the fuzzy optimization into practice. In conclusion, the main objective of this research is to provide fuzzy logic gear shifting control for an AMT system that maximizes efficiency while reducing emissions and fuel consumption. The proposed control considered the engine speed, required traction torque, and engine temperature as inputs, as the latter two impact catalyst efficiency., which was calculated using the longitudinal dynamic formulation of the vehicle. The vehicle's AMT receives commands from the fuzzy operator to shift into and out of gear based on the driving conditions. The method previously described in optimizes the fuzzy AMT control. It was created to specify ideal membership functions; however, it is added in this paper. the capacity to determine the most appropriate control rule and to optimize the control rules with their corresponding weights technique of defuzzification

II. LITERATURE SURVEY

Writers: [J. Smith et al.] In order to improve vehicle performance, this study investigates the use of fuzzy logic in gear shifting techniques optimization. The effect on acceleration, speed, and general drivability is examined in the study

Writers: [R. Gupta et al.] In this article, Gupta et al. explore how fuzzy logic can reduce fuel consumption by cleverly modifying transmission gear shifts. The study assesses fuzzy control's efficacy under various driving circumstances.

Writers: [L. Chen, et al.] Chen et al. investigate the potential of fuzzy gear shifting management to reduce engine emissions with an emphasis on the environmental impact. The trade-offs between emission reductions and performance enhancements are evaluated in this paper.

Writers: [Kim, S., and others] Kim et al. compare fuzzy logic- based transmission control with conventional techniques in their study. The study demonstrates the benefits and drawbacks of fuzzy logic in terms of maximizing emissions, fuel efficiency, and vehicle performance.

Writers: [Y. Wang et al.] This work investigates adaptive gear changing algorithms for hybrid electric vehicles by extending the application of fuzzy logic to this new technology. The study looks at the particular difficulties presented by hybrid powertrains and how they affect emissions, performance, and fuel economy.

Writers: [H. Li, et al.] Li and associates demonstrate the practical application of fuzzy gear shifting control on a test vehicle. This study explores the benefits and practical issues that arose during on-road testing, offering valuable insights into the practicality of applying fuzzy logic to actual car systems. For a minus symbol, use a hyphen. Use commas or periods to punctuate equations that are a part of a sentence. Authors: [Q. Zhang and others] Zhang et al. look into how machine learning and fuzzy logic might be combined to provide intelligent transmission control. The study investigates how a hybrid approach might further enhance vehicle performance, fuel economy, and engine emissions.

III. PROPOSED METHODOLOGY

System Modeling: Construct a detailed model of the vehicle's dynamics and drivetrain. Engine representations

Included should be the drivetrain, transmission, and any other relevant components. Ensure that the model takes into account every significant factor affecting emissions, fuel consumption, and performance.

Design a fuzzy logic controller that, given inputs from a range of sensors (e.g., throttle position, vehicle speed, engine RPM, etc.), determines the optimal gear shift recommendation. In constructing the fuzzy logic system, it is crucial to strike a balance between fuel consumption, performance, and pollution. Define the terms "measures of performance" and set exact benchmarks for improvements in vehicle performance, fuel economy, and emissions from engines. Examples of these measurements include emissions levels, acceleration times, fuel efficiency, and driveability indices.

Data Collection and Pre-processing: Real-world data or simulations can be used to collect relevant input data for the fuzzy logic controller. Verify the data's compatibility with the model and preprocess it to cut down on noise.

Training and Validation: Train the fuzzy logic controller with the collected data. Test the controller's performance in a range of scenarios and driving conditions to ensure that it is robust and adaptable.

Simulation and Analysis: Use the fuzzy gear shifting control system in a simulation environment that replicates

ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)

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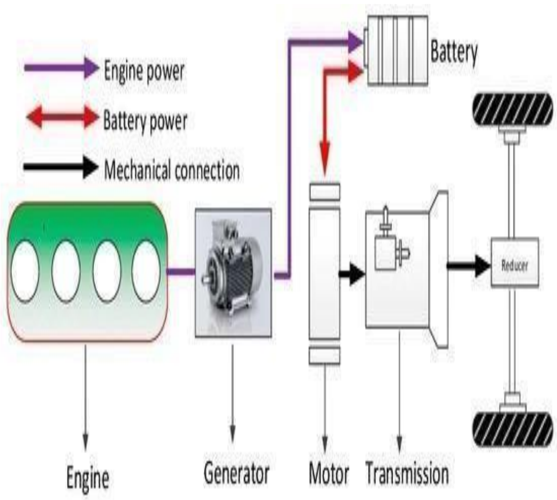
various driving situations. Analyze the results of the simulation to see if the vehicle's performance, fuel efficiency, and engine emissions have improved from the baseline scenarios.

Optimization Iterations: Adjust the parameters and design of the fuzzy logic controller in light of the results of the simulation. To get the best possible balance between performance, fuel efficiency, and emissions reduction, adjust the system.

Assessment using Baseline Systems: Evaluate the improved fuzzy gear shifting control system's performance against traditional transmission control systems. Examine the improvements in terms of fuel efficiency, vehicle dynamics, and emissions reduction.

Reporting and Documentation: Maintain detailed records of every step of the process, including the specifications of the model, the fuzzy logic controller's parameters, the data sources, the simulation's results, and the testing conducted in real life. Compose a comprehensive report that outlines the steps taken and the outcomes.

A. Architecture design



IV. VEHICLELONGITUDINALDYNAMICS

Acceleration: A part of longitudinal dynamics is the study of a vehicle's acceleration while accounting for the interactions between the engine, gearbox, and drivetrain.

Braking: Analyzing the effects of longitudinal dynamics on the braking system, considering factors such as deceleration rates and braking force distribution

The way that driver actions, such as using the brake and throttle, affect the car's motion is one facet of longitudinal dynamics.

The way the brake and throttle inputs interact influences the vehicle's overall feel, acceleration, and deceleration under different driving conditions.

The way the tires and the road surface interact is a crucial aspect of longitudinal dynamics.

Consideration must be given to traction, slide, and grip levels, especially when attempting to optimize braking and accelerating performance.

The mass distribution along the longitudinal axis of the vehicle affects how it reacts to acceleration and deceleration.

Knowing the mass distribution and inertia rules makes it easier to anticipate the vehicle's under different circumstances.

Longitudinal dynamics is largely influenced by the gearbox and engine systems.

The powertrain's total performance, which includes torque delivery and gear shifting, determines the vehicle's acceleration and fuel efficiency.

Analyzing the vehicle's speed variations over time is essential to comprehending its longitudinal dynamics.

Comprehending velocity profiles is vital for refining gear shifting tactics and elevating total efficiency.

Maintaining longitudinal dynamics is essential for keeping the car stable, particularly when stopping and accelerating.

Through the prevention of wheel slippage and the maintenance of effective power delivery, traction control systems contribute to the efficient longitudinal dynamics.

The distribution of load on the front and rear axles is impacted by longitudinal weight transfer, which happens during acceleration and braking.

Stability and ideal tire traction depend on the effective regulation of dynamic load transfer.

Advanced driving assistance systems (ADAS), which include adaptive cruise control, collision avoidance, and emergency braking systems, usually incorporate control over longitudinal dynamics..Fuel efficiency and emissions are impacted by longitudinal dynamics, particularly during acceleration stages.

Fuel economy and environmental effect can be reduced by optimizing engine control and gear shifting.

Vehicle performance and driveability are greatly enhanced by longitudinal dynamics.

A seamless, responsive, and secure driving experience is ensured by the efficient handling of longitudinal forces

It is crucial to comprehend and model these characteristics of longitudinal dynamics in order to optimize fuzzy gear shifting control. Based on the current driving conditions, fuzzy logic controllers can use this information to make judgments in real- time about emissions, fuel efficiency, and gear adjustments.

V. DYNAMIC SIMULATION

During the development stage of a mechatronic and control system design, the co-simulation technique is utilized while creating a physical system. The vehicle model under investigation was employed in the simulations utilized in this work, which were produced using the multibody dynamic analysis tool Adams TM (Automatic Dynamic Analysis of

ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)

Volume 11 Issue 7 July 2024

Mechanical Systems). As was previously noted, the variables related to longitudinal dynamics were regulated using the Adams and MATLAB/Simulink TM interface.

A. Gear shifting parameters

In order to prevent unstable gear changing, it is essential to set certain parameters for an accurate description of the vehicle behaviour. As suggested by Yin et al. (2007), a gear shifting time of one second was used in the simulations that were run. For stabilization, the dwell period between two successive gear shifts is also crucial. This is necessary to maintain comfort levels and prevent chattering (Casa vola etc al. 2010).

In order to prevent gear change instability, which is caused by the speed decrease that occurs just before the clutch disengages, separating the engine from the powertrain, Xi et al. (2009) state that the downshift occurs five km/h slower than the upshift speed.

B. Vehicle parameters

Vehicle Speed: Definition: The selection of gears is directly influenced by the fundamental parameter of vehicle speed. Various gear ratios may be needed for varying speed rangesin order to get the best possible performance, fuel economy, and emissions control.

Function of Fuzzy Logic Controllers: Fuzzy logic controllers should take the speed into account when deciding whether or not to shift gears and, if so, which gear is best.

The engine's rotational speed is measured in engine revolutions per minute, or RPM. Proper gear changing is strongly related to maintaining an efficient engine speed range for power and fuel efficiency.

Function of Fuzzy Control: Fuzzy logic should consider the current engine RPM to prevent gear change that could cause inefficient operation or unnecessary strain on the engine.

The driver's accelerator pressure is indicated by the throttle position. It directly affects the engine's power production and, thus, the need for gear changes.

Function of Fuzzy Control: Fuzzy logic should evaluate the throttle position in order to anticipate the driver's intentions and adjust gear shifting appropriately.

The brake input indicates the driver's intention to slow down or stop. It is essential for maximizing gear shifts and predicting future driving conditions.

Function of Fuzzy Control: Fuzzy logic should react to brake input in order to ensure smooth downshifting and optimal energy recovery during braking.

The vehicle load includes both passenger and cargo weight. The characteristics of acceleration and deceleration may be affected by heavier weights, which could affect the gear selection.

Function of Fuzzy Control: Fuzzy logic should consider the current load when modifying gear shifting for optimal performance and fuel efficiency.

Depending on whether the road slopes upward or downward, the vehicle's energy consumption changes. Enhancing gear changes is crucial to account for changes in road grade.

Function of Fuzzy Control: Fuzzy logic should take the road gradient into account in order to estimate energy requirements and adjust gears accordingly.

Transmission efficiency is the measure of how effectively engine power is transferred to wheel power by the transmission system. Temperature and wear could cause it to alter.

Function in Fuzzy Control: Fuzzy logic should consider the transmission efficiency in order to make well-informed decisions regarding gear changes that optimize overall efficiency.

Both engine and outside temperatures can affect how well a number of vehicle systems, including the gearbox and engine, operate.

The purpose of fuzzy control is to optimize gear shifting under a range of operating conditions by using fuzzy logic to adapt to temperature variations.

Numerous driving modes that alter specific performance factors are offered by some cars. The driving mode chosen may affect the desired trade-off between performance and efficiency.

Function of Fuzzy Control: Depending on the selected driving mode, gear changing strategies should be tailored using fuzzy logic.

The state of the vehicle's catalytic converter and other pollution control systems may have an effect on how much emissions it produces.

The purpose of fuzzy control is to optimize emissions control by adjusting gear shifting based on the current status of the emission control systems.

Advantages:

Fuzzy logic controllers allow for real-time adaptability to dynamic changes in driving situations, such as shifting traffic patterns, road gradients, and speed fluctuations.

Fuzzy gear shifting control maximizes gear changes based on the current driving conditions, hence improving fuel efficiency. Optimal gear changing may reduce stress on the engine and gearbox components, hence extending their lifespan.

Fuzzy gear shifting control can assist lower engine emissions because it minimizes situations where the engine is running richly or leanly on fuel and promotes efficient operation.

Because fuzzy control systems are capable of learning to conform to the unique driving patterns of different drivers, they offer a more customized driving experience.

Based on the available sensor inputs and the driving conditions, real-time fuzzy logic generates decisions.

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ISSN (Online) 2394-2320

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Disadvantages:

Creating and implementing a fuzzy logic control system for the best gear changes might be challenging. Developing, testing, and improving the fuzzy rules and membership functions can be very resource-intensive.

Developing effective fuzzy rules and simulating the intricate relationships between various input factors require a deep comprehension of the vehicle's dynamics.

systems using fuzzy logic rely on preset rules that are derived from expert knowledge. Human driving behaviour, however, is very individualized and complex.

Fuzzy logic functions by utilizing pre-established rules and the current sensor inputs. It might not be able to precisely estimate the driving conditions of the future.

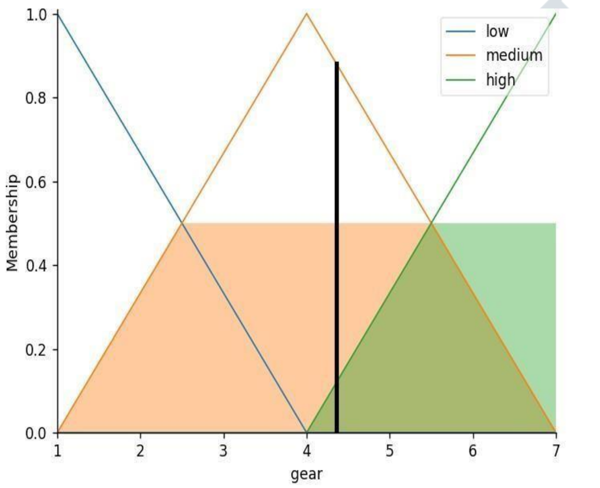
It's possible for drivers to be resistant to alterations to their usual driving experiences, particularly if the fuzzy gear shifting mechanism seems strange or unpredictable.

The intricacy of fuzzy logic systems could present difficulties for professionals who perform maintenance and repairs. Expertise in diagnosing and troubleshooting control system problems may be needed.

The use of fuzzy logic control systems may result in the adoption of more power-hungry electronic components.

Output Results:

Sample1:

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Optimal Gear: 4.357142857142857
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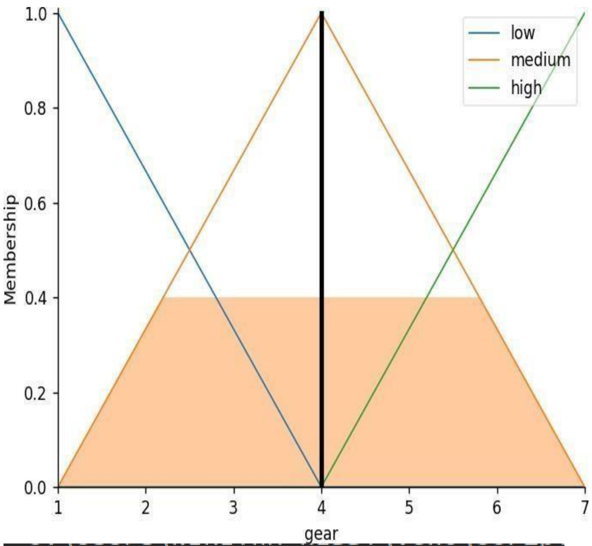
Sample 2:

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Optimal Gear: 3.9999999999999996
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VI. CONCLUSION:

This study suggests a multi-objective optimization for an AMT fuzzy control to improve vehicle acceleration, lower engine emissions, and increase fuel efficiency. The optimization problem was formulated using the Adaptive-Weight Genetic Algorithm as a basis. method that adjusts the fuzzy membership functions, the control rules with their associated weights, and the defuzzification procedure to find the best trade-off solutions among the optimization criteria The FTP-75 cycle was completed by the fuel economy

solution, saving 24.49% of the gasoline. However, this strategy does not reduce engine warm-up time, which lengthens the catalyst's inefficient run and increases emissions. Even though this enables the engine to run in a more fuel-efficient sector, acceleration performance is also adversely affected by the many torque supply interruptions brought on by the consecutive upshifts. The best performance choice is to operate the engine in situations where the ICE output power may affect performance, delay upshifts, avoid clutch decoupling, and match the FTP-75 target speed profile more closely .

This method therefore runs the engine at high speed and low torque, which match the least efficient regions of the emissions and fuel consumption maps. Fuel usage rises by 11.56% and NOx emissions rise by 53.19% as a result. Compared to the traditional gear shifting approach, this one provides a quick warm-up during the cold start part of the cycle, resulting in a reduction of 12.02% and 6.09%, respectively, in CO and HC emissions.

The low emission solution's behaviours falls between the best performance and fuel economy categories. Once the engine achieves the stable temperature, this AMT solution modifies the strategy to save fuel. This tactic slows down the upshifts during the cold start phase in order to accelerate engine warm- up, increase catalyst efficiency, and reduce exhaust emissions. But this regime also suggests a rise in gasoline use. In comparison to the standard option, the minimum emissions strategy offers 20.41% fuel savings and a 6.09% reduction in HC, 18.30% NOx, and 26.90% CO emissions.

The best-compromised solution reduces CO emissions by 29.20%, HC emissions by 12.90%, NOx emissions by 17.02%, and fuel savings of 19.72% as compared to the traditional method. Additionally, it provides the optimum balance of performance, fuel economy, and exhaust emissions. This solution provides a gear shifting strategy that is similar to the low emission (i.e., lower traction torque demand) boosting the car's acceleration capabilities, even if the best-compromised method performs the gear shifts under more favourable conditions. In the end, it is found that the right gear changing management for AMT considerably improves the vehicle's acceleration performance, fuel efficiency, and engine emissions.

Once the engine has steadied, the vehicle can change its gear shifting technique to save fuel during the cold start phase of the cycle and reduce emissions for the remaining portions of the FT75 speed profile. This is made feasible by the control the of system's incorporation of engine temperature data, Therefore, future studies need to evaluate the behaviours of these fuzzy AMT controllers under different driving scenarios.

REFERENCES

[1] Jia, S., Yan, G., and Shen, A.: 'Traffic and emissions impact of air pollution charge fee and subsidy combination scenarios,' J. Cleaner Prod., Part 1, 2018, 197, pp. 678-689.

[2] 'A novel multi-parameter coordinated shift control approach for an automated manual transmission based on fuzzy inference,' Proc. Inst. Mech. Eng. D, J. Auto mob. Eng., 2017, 231, (5), pp. 684-699.Zhang, L., Zhang, X., Han, Z., et al.

[3] 'Thermodynamic analysis of active modular internal combustion engine concept: targeting efficiency gain and carbon dioxide emissions reduction of gasoline engines,' Mauti, N., Radica S., Int. J. Energy Res., 2018, 42, (9), pp. 3017-3029.

[4] road motor vehicles - determination of hydrocarbons, carbon monoxide, nitrogen oxides, carbon dioxides, and particulate matter in exhaust gas', NBR6601. Rio de Janeiro, Brazil, ABNT, 2012.

[5] 'Design of a reduced-order non-linear observer for vehicle velocities estimate,' Guo, H., Chen, H., Cao, D., et al., IET Control Theory., 2013, 7, (17), pp. 2056-2068.

[6] Brezina, Tomas, Zdenek Hadas, are the players. "Using of Co-simulation ADAMS-SIMULINK for development of mechatronic systems." 14th International Symposium on MECHATRONIKA, 2011 IEEE, 2011.

[7] Kang et al., et al. "Coordinated vehicle traction control based on engine torque and brake pressure under complicated road conditions." 50.9 (2012) Vehicle System Dynamics.

[8] "Application of time-optimal strategy and fuzzy logic to the engine speed control during the gear-shifting process of AMT," Yin, Xue, and Yun Cai. 2007. Fuzzy Systems and Knowledge Discovery. Fourth International Conference on FSKD, Vol. 4.

[9] F. M. Santiciolli, E. S. Costa, J. J. Eckert, H. J. Dionsio and F. G. Dedini "Gear Shifting Optimization Strategy for Brazilian Vehicles and Traffic," Proceedings of the 22nd International Congress of Mechanical Engineering, Ribeiro Preto, Brazil, 2013.

[10] T. D. Gillespie, Fundamentals of Vehicle Dynamics, 1992. Warrendale, 1st edition, Society of Automotive Engineers.

[11] R. N. Jazar 2008. Theory and applications of vehicle dynamics. 1st edition, Springer, New York.

[12] 'Genetic fuzzy logic controller: an iterative evolution algorithm with new encoding approach,' Chiou, Y.C., Lan, L.W., Fuzzy Sets Syst., 2005, 152, (3), pp.

[13] Krithika, V., and C. Subramani: 'A comprehensive study on the selection of hybrid vehicles and power converters, as well as control strategies for hybrid electric vehicles,' Int. J. Energy Res., 42, (5), 2018.