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**OPTIMASI STRATEGI MENGEMUDI "PULSE AND GLIDE" UNTUK MENINGKATKAN EFISIENSI ENERGI KENDARAAN LISTRIK
BERBASIS ALGORITMA GENETIKA**
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INTISARI

OPTIMASI STRATEGI MENGEMUDI "PULSE AND GLIDE" UNTUK MENINGKATKAN EFISIENSI ENERGI KENDARAAN LISTRIK BERBASIS ALGORITMA GENETIKA

Oleh:

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Efisiensi energi kendaraan listrik dipengaruhi oleh strategi mengemudi, tetapi beberapa penelitian berbasis model sebelumnya mengabaikan karakteristik lintasan sehingga model menjadi kurang akurat. Penelitian ini bertujuan merancang model simulasi berbasis MATLAB Simulink yang mempertimbangkan model lintasan untuk optimasi strategi *pulse and glide* berbasis algoritma genetika, serta membandingkan konsumsi energi pada jalur kurvatur minimum dan jalur jarak minimum guna memperoleh rekomendasi strategi dan jalur optimal bagi kendaraan Semar Proto 4.0.

Model simulasi dikembangkan secara modular berdasarkan data spesifikasi teknis kendaraan, mencakup model baterai *Rint*, kontroler *buck converter*, *drivetrain*, serta model bodi kendaraan yang memperhitungkan gaya hambat aerodinamik, gelinding, dan belokan. Data lintasan diperoleh dari Google Earth Pro, kemudian diproses melalui transformasi koordinat UTM, interpolasi, dan optimasi posisi lateral berbasis *quadratic programming* untuk menghasilkan jalur jarak minimum dan jalur kurvatur minimum, profil tanjakan dan kurvatur yang didapatkan dari jalur hasil optimasi tersebut selanjutnya digunakan sebagai dasar model lintasan. Keluaran simulasi divalidasi menggunakan data uji kendaraan, dengan membandingkan konsumsi energi dan profil kecepatan yang dihasilkan model terhadap data uji. Optimasi strategi *pulse and glide* selanjutnya dilakukan menggunakan algoritma genetika dengan variabel desain berupa batas kecepatan atas, batas kecepatan bawah, dan jumlah percepatan.

Hasil validasi menunjukkan bahwa penambahan model lintasan meningkatkan akurasi nilai konsumsi energi dengan galat kurang dari 0,5%, sedangkan tanpa model lintasan galat mencapai sekitar 14% terhadap data aktual. Optimasi strategi *pulse and glide* pada lintasan Jakarta International ePrix dan International Lusail Circuit menunjukkan bahwa jalur jarak minimum secara konsisten menghasilkan total *losses* lebih rendah dibandingkan jalur kurvatur minimum, dengan peningkatan efisiensi energi sebesar 8,955% dan 10,144% dibandingkan capaian historis Semar Proto 4.0.

Kata Kunci: Optimasi, Strategi Mengemudi, Algoritma Genetika, Kendaraan listrik, Efisiensi Energi.

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ABSTRACT

OPTIMIZATION OF "PULSE AND GLIDE" DRIVING STRATEGY TO IMPROVE ENERGY EFFICIENCY OF ELECTRIC VEHICLES BASED ON GENETIC ALGORITHM

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Electric vehicle energy efficiency is influenced by driving strategies, however, several previous model-based studies have neglected track characteristics, thereby reducing the accuracy of the resulting models. This study aims to develop a MATLAB Simulink-based simulation model that incorporates track characteristics for pulse and glide strategy optimization using a genetic algorithm. Furthermore, energy consumption on minimum curvature and minimum distance paths is compared to determine the optimal driving strategy and path recommendation for the Semar Proto 4.0 electric vehicle.

The simulation model was developed using a modular architecture based on the vehicle technical specifications, consisting of a battery model, controller, drivetrain, and vehicle body model that accounts for aerodynamic drag, rolling resistance, and cornering forces. Track data were obtained from Google Earth Pro and processed through UTM coordinate transformation, interpolation, and lateral position optimization using quadratic programming to generate minimum distance and minimum curvature paths. The slope and curvature profiles derived from these optimized paths were used as the basis for the track model. The simulation outputs were validated against vehicle test data by comparing the model-generated energy consumption and speed profiles with the measured results. Pulse and glide strategy optimization was performed using a genetic algorithm, with the upper speed limit, lower speed limit, and number of acceleration events serving as the design variables.

The validation results show that incorporating the track model improves the accuracy of energy consumption predictions, reducing the error to less than 0.5%, whereas the model without track representation exhibits an error of approximately 14% relative to the experimental data. Pulse and glide strategy optimization on the Jakarta International ePrix Circuit and Lusail International Circuit demonstrates that the minimum distance path consistently results in lower total energy losses than the minimum curvature path, achieving energy efficiency improvements of 8.955% and 10.144%, respectively, compared with the historical performance of the Semar Proto 4.0 electric vehicle.

Keywords: *Optimization, Driving Strategy, Genetic Algorithm, Electric Vehicles, Energy Efficiency.*