

Development of Integrated Technologies for Dynamic Wireless Power Transfer and Autonomous Drive

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Electric vehicle proliferation is constrained by limited battery range and lengthy charging times. Dynamic Wireless Power Transfer (DWPT) offers a transformative solution, enabling fully unmanned, continuous operation when integrated with autonomous driving. However, implementing DWPT on public roads faces challenges from inevitable construction errors, causing misalignment between vehicles and coils. Conventional sensors (LiDAR, cameras, GNSS) rely on geometric features and cannot detect underground coils. Consequently, navigation systems using Normal Distributions Transform (NDT) scan matching and vector maps suffer coordinate registration errors, severely degrading power transfer efficiency.

To address this, we propose a high-precision position estimation and control framework requiring no extra external sensors. Utilizing a Series-Series resonant WPT system, our approach improves upon conventional models that assume constant transmitter self-inductance. Accounting for the coil's self-inductance varying with spatial alignment, we formulated a theoretical model for the receiver's DC current incorporating spatial variations of both self- and mutual inductance. This DC current data is fused with vehicle dynamics via an Unscented Kalman Filter (UKF), feeding precise steering corrections directly to the autonomous driving control module.

Validations utilized a fully by-wire autonomous EV running Autoware. Repeated parking tests relying solely on NDT scan matching demonstrated a lateral control standard deviation of just 7.0~8.0mm (Fig. 1). These results indicate that real-world lateral misalignment stems primarily from infrastructure installation and map errors, rather than vehicle control instability. Furthermore, static WPT measurements under varying offsets proved that the proposed variable-inductance model accurately reproduces experimental current responses across wide misalignments. Conversely, traditional constant-inductance models exhibited significant deviations from measured currents (Fig. 2).

Simulations incorporating mapped inductance characteristics into the UKF demonstrated remarkable dynamic positioning accuracy. Compared to conventional methods yielding a 12mm average lateral estimation error, our method reduced this to merely 1.2mm (Fig. 3), surpassing standard LiDAR precision. Under a realistic scenario with a 150mm lateral map error, conventional uncorrected navigation resulted in 82.3% power transfer efficiency. Continuously applying UKF-estimated positions for real-time trajectory correction improved overall efficiency to 87.2% (Fig. 4). This translates to a 28% reduction in total power loss, enhancing DWPT system viability. Ultimately, this framework mitigates the influence of unavoidable construction errors, promoting the practical application of continuous autonomous mobility.

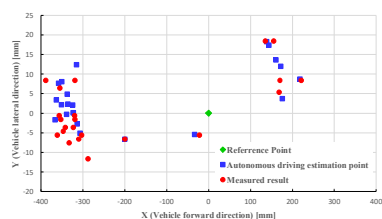


Fig. 1 Distribution of Vehicle Parking Accuracy

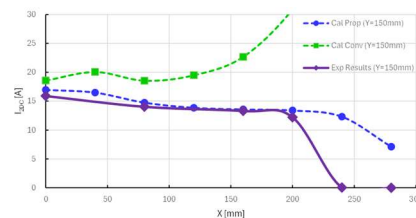


Fig. 2 Comparison of Calculation Results and Experimental Result(Y=150mm)

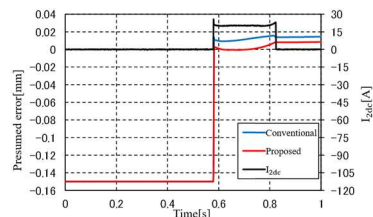


Fig. 3 Estimation Error from the Simulation

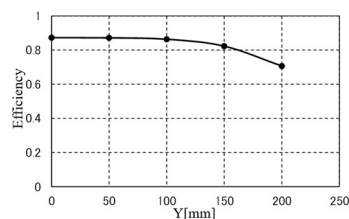


Fig. 4 Efficiency VS. Lateral Deviation Y