

ROBUST TEMPERATURE DRIFT COMPENSATION FOR FIBER-OPTIC GYROSCOPES VIA LSTM-PINN INTEGRATION

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Abstract

Fiber-Optic Gyroscopes (FOGs) are widely used in high-precision inertial navigation systems due to their high sensitivity, reliability, and immunity to electromagnetic interference. However, their performance is significantly affected by temperature variations, which induce bias drift and long-term instability in the output angular rate. Traditional temperature compensation techniques—such as polynomial fitting, lookup tables, and Kalman filtering—often fail to capture nonlinear temporal dependencies and complex thermodynamic behaviors present in real-world environments. This project proposes a **Temperature Drift Compensation Method for Fiber-Optic Gyroscopes Based on LSTM-PINN**, which integrates a Long Short-Term Memory (LSTM) neural network with a Physics-Informed Neural Network (PINN) constraint. The LSTM component models nonlinear temporal correlations between temperature, gyro output, and their derivatives, while the PINN component embeds physical drift dynamics into the loss function, ensuring that predictions remain consistent with thermodynamic principles. Synthetic FOG data are generated using a first-order temperature-driven drift model combined with realistic noise and bias characteristics. The hybrid LSTM-PINN framework is trained using both supervised drift labels and a physics-based residual constraint, enabling improved generalization and stability. Experimental evaluation demonstrates that the proposed approach significantly reduces angular rate error compared to uncompensated signals, achieving lower RMSE and improved drift prediction accuracy. The proposed method enhances robustness, interpretability, and reliability of FOG systems operating under varying environmental conditions, making it suitable for aerospace, defense, robotics, and autonomous navigation applications.