Real-Time Intelligent Control System to Address Faults for DC Motors

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Introduction

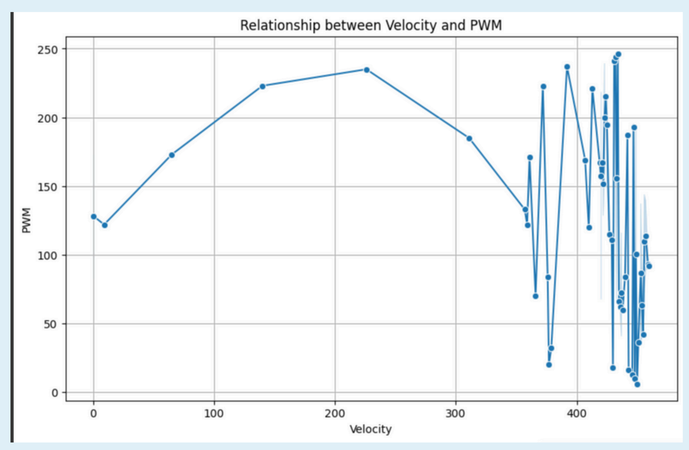
This project focuses on enhancing the modeling of Permanent Magnet DC (PMDC) motors using machine learning. We developed models to predict motor velocity from voltage inputs and rotor angular velocity from pulse width modulation (PWM) signals.

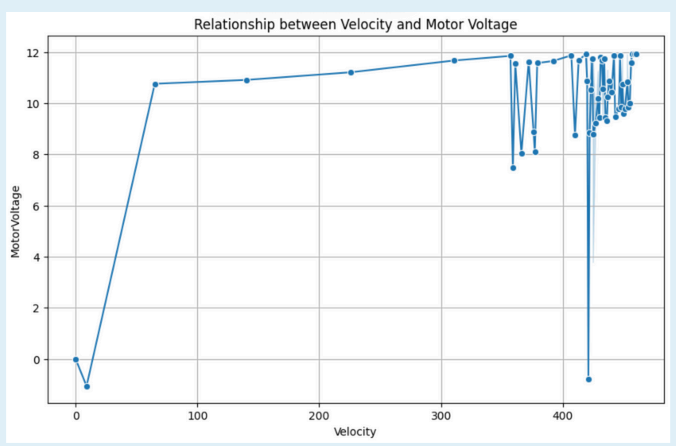
These predictive models are then combined to estimate rotor temperature, a critical but challenging parameter to measure directly. Our approach aims to improve motor control and efficiency in practical applications.

Problem

Accurately predicting key parameters of Permanent Magnet DC (PMDC) motors, such as motor velocity, rotor angular velocity, and rotor temperature, is challenging due to the nonlinear behavior of these systems. Traditional methods often fall short, especially in estimating rotor temperature, which is crucial for motor efficiency and longevity.

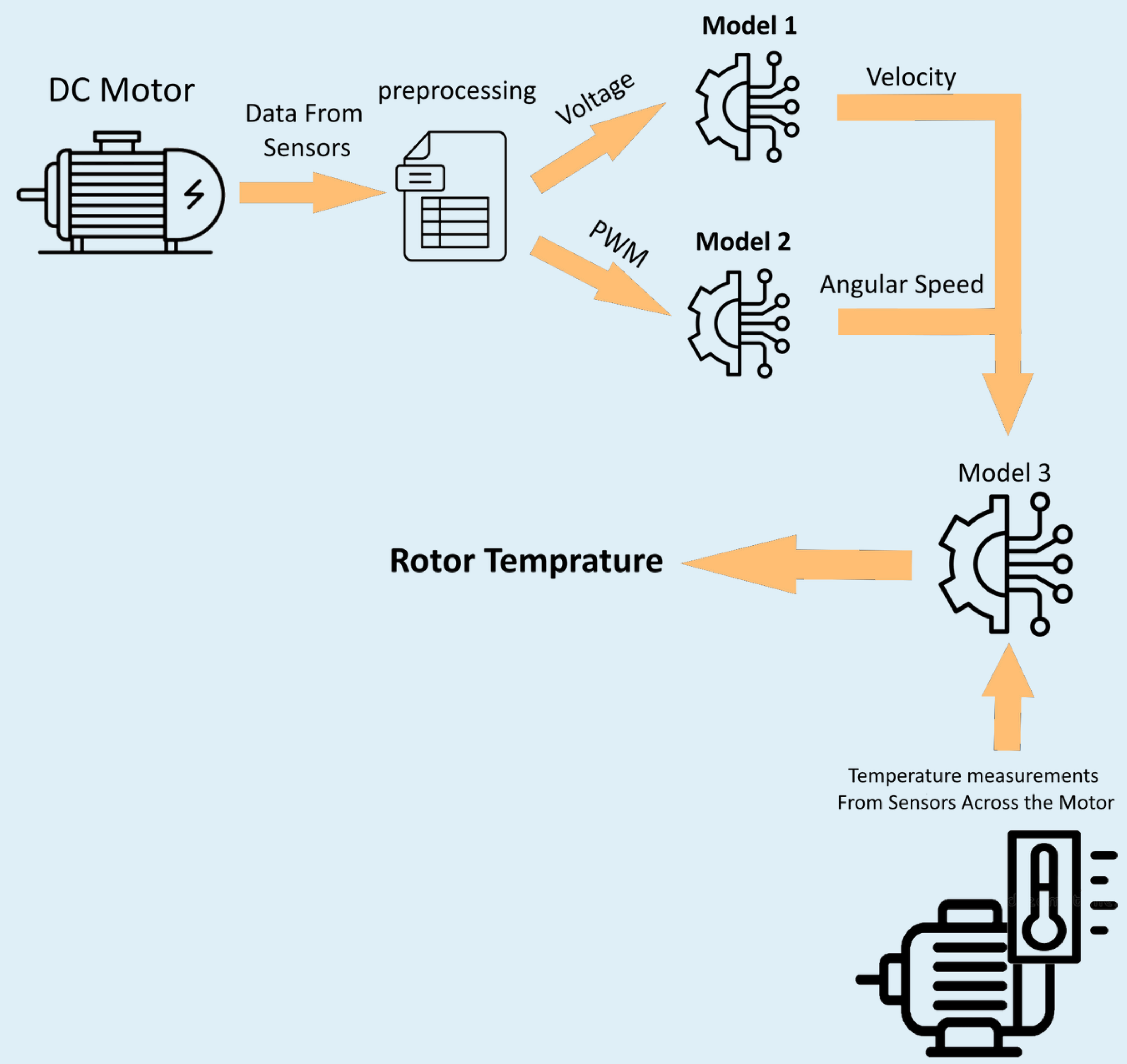
This project addresses these issues by using machine learning to develop models that improve the accuracy of these predictions, enhancing motor control and performance in practical applications.





Methodology

Our methodology involves collecting and preprocessing sensor data from the DC motor to develop models predicting motor velocity, rotor angular velocity, and rotor temperature. We train and validate these models using machine learning algorithms and integrate them for real-time motor control. *Model 1* predicts motor velocity, *Model 2* estimates rotor angular velocity, and *Model 3* combines these outputs to estimate rotor temperature. This approach enhances motor control, efficiency, and reliability.

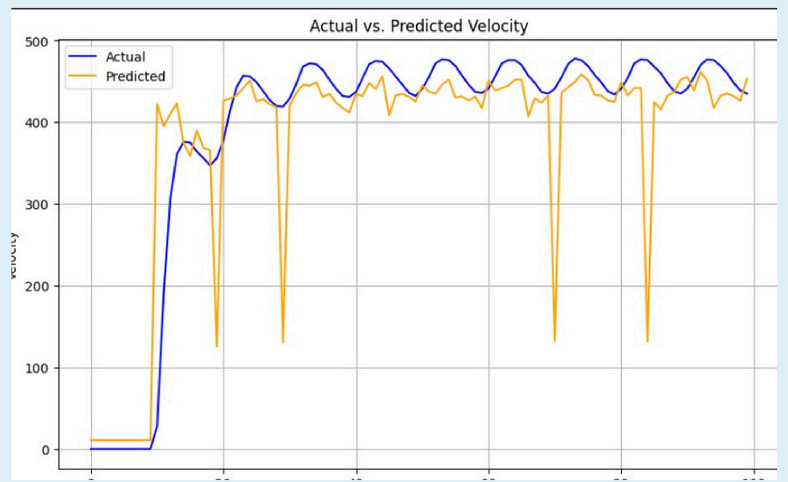


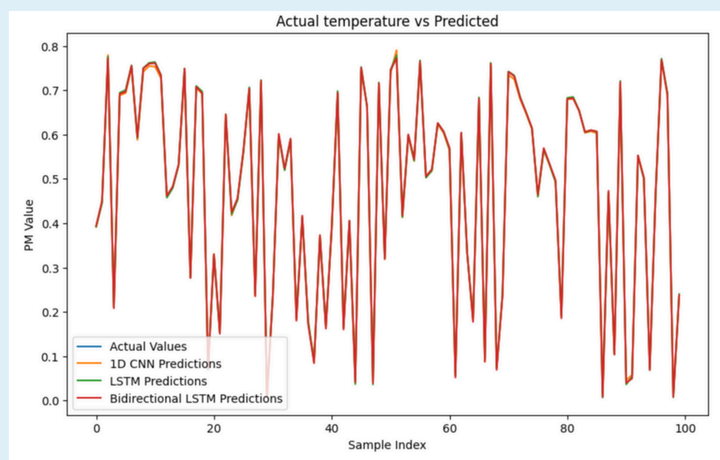
Results

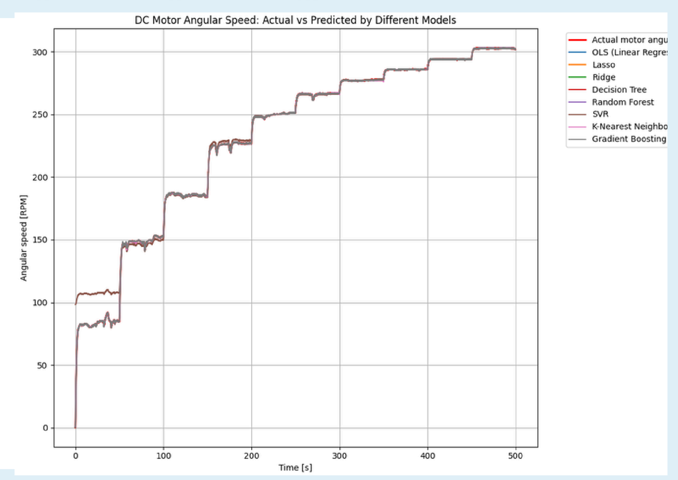
Model 1			
Model / Metric	R^2	Mean Squared Error	Mean Absolute Error
Deep Neural Network	0.9114	3463.83	28.06

Model 2			
Model / Metric	R^2	Mean Squared Error	Mean Absolute Error
OLS (Linear Regression)	1.0	$1.58e-24$	$1.18e-12$
SVR	0.9875	55.87	2.84
Gradient Boosting	0.9999	$4.02e-2$	0.100

Model 3			
Model / Metric	R^2	Mean Squared Error	Mean Absolute Error
1D CNN	0.99	$3.47e-5$	$4.15e-3$
LSTM	0.9993	$2.83e-5$	$3.93e-3$
Bidirectional LSTM	0.9994	$2.51e-5$	$3.79e-3$







Conclusion and Future work

By addressing the challenges in accurately modeling Permanent Magnet DC (PMDC) motors, this project demonstrates the potential of machine learning to enhance motor performance significantly. We have achieved outstanding results, showcasing substantial improvements in motor control, efficiency, and reliability, paving the way for more effective use of PMDC motors in various practical applications. Future work will focus on developing a real-time controller for temperature, further enhancing the motor's performance and longevity.