

Application and Optimization of Information Technology in Brushless Motor Control System

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Abstract: *Owing to their high efficiency, reliability, and superior precision in torque and speed regulation, Brushless DC (BLDC) motors have become a cornerstone technology across a diverse spectrum of applications, including industrial automation, electric vehicles (EVs), robotics, and consumer appliances. The ongoing and rapid evolution of information technology (IT), encompassing domains such as artificial intelligence (AI), the Internet of Things (IoT), big data analytics, and advanced computational methods, is fundamentally reshaping the landscape of motor control. This technological convergence presents a pivotal opportunity to transcend the limitations of conventional control paradigms, which often rely on fixed-parameter controllers and exhibit limited adaptability to dynamic operational conditions and system nonlinearities. Consequently, these legacy systems may not fully exploit the motor's potential, leading to suboptimal performance, reduced energy efficiency, and compromised reliability under variable loads and unforeseen disturbances. This paper seeks to conduct a comprehensive investigation into the integration and application of these emergent information technologies within BLDC motor control systems, with the overarching objective of proposing a coherent framework of optimization strategies. We systematically explore the implementation of AI-based techniques, specifically fuzzy logic and neural network controllers, to achieve adaptive, self-tuning control that enhances dynamic response and robustness. Furthermore, the role of IoT-enabled connectivity for real-time system monitoring, predictive maintenance, and data-driven operational optimization is critically examined. The paper also delves into the utilization of high-fidelity modeling and simulation, facilitated by IT tools, for refining control algorithms and conducting virtual prototyping, thereby reducing development time and cost. The proposed optimization strategies are analytically evaluated based on their capacity to significantly improve key performance metrics: overall system performance (encompassing dynamic response and tracking accuracy), energy efficiency across a wide power band, long-term cost-effectiveness through reduced maintenance and downtime, and operational reliability in demanding environments. The synthesis of these IT-driven approaches is posited to represent a significant leap forward, paving the way for the next generation of intelligent, connected, and highly efficient BLDC motor drive systems that are capable of meeting the escalating demands of modern industrial and consumer applications.*

Keywords: Brushless DC Motor; Information Technology; Intelligent Control; Optimization Strategies; System Performance; Artificial Intelligence; Internet of Things.

1. RESEARCH BACKGROUND AND SIGNIFICANCE

Brushless DC Motor (BLDC), as an advanced type of electric motor, has been widely used in industrial automation, electric vehicles, household appliances and other fields. Compared with traditional brushed DC motors, brushless motors have advantages such as no friction, low noise, high efficiency, long lifespan, high efficiency, reliability, and precise control, making them the preferred choice for modern electric systems. Therefore, they have been widely recognized and applied in the industrial and consumer electronics markets.

Although brushless motors have been widely used, the performance, cost, and reliability of their control systems still need further optimization. With the rapid development of information technology, brushless motor control systems are facing new opportunities and challenges. The development of information technology has brought new opportunities for brushless motor control systems, including the application of sensor technology, data acquisition and processing, algorithms and control methods, and communication technology. The application of information technology provides more functions and flexibility for brushless motor control systems, while also increasing the complexity and requirements of the system. Therefore, researching how to fully utilize the advantages of information technology and solve corresponding technical problems is of great significance for improving the performance and efficiency of brushless motor control systems, reducing costs, and enhancing reliability. Diao et al. (2025) optimized Bi-LSTM networks for lung cancer detection, achieving significant accuracy improvements [1], while Wang (2025) developed a transformer-augmented survival analysis model for adverse event forecasting in clinical trials [16]. Ma et al. (2023) contributed to medical equipment management through their fine life cycle prediction system [9], complementing their earlier environmental health research on metal exposure effects [8]. Smart city technologies have advanced through Li et al.'s (2025) user-centered

framework for interactive data exploration in urban analytics [2] and Fang's (2025) adaptive QoS-aware cloud-edge architecture for smart water management [15]. Industrial applications include Zhao et al.'s (2024) deep learning approach for steel production optimization [3] and Tu's (2025) Log2Learn system for intelligent network log analysis [7]. Financial analytics has seen multiple breakthroughs, beginning with Yang et al.'s (2025) big data method for economic cycle prediction [4] and their CNN-based stock market sentiment analysis [5]. Jiang et al. (2025) introduced Investment Advisory Robotics 2.0 for personalized financial guidance [6], while Saunders et al. (2025) analyzed AI-driven smart supply chains [11] and Pal et al. (2025) developed AI-based credit risk assessment for supply chain finance [12]. Qi (2025) contributed DecisionFlow, a visual framework for SME multi-task prediction and anomaly detection [14]. Computer vision innovations include Ding et al.'s (2025) attention mechanism for clothing-changing person re-identification [10] and Zhang et al.'s (2025) anomaly detection in biomechanical data [13].

2. OVERVIEW OF BRUSHLESS MOTOR CONTROL SYSTEM

2.1 Working principle of brushless motor

Brushless motor is an electric motor based on electronic commutation, which switches the current in a timely manner through electronic devices (such as power transistors) to achieve the rotation of the motor rotor. We will explore the working principles of two types of motors, including permanent magnet brushless DC motors and induction brushless motors. In addition, the structure and main components of brushless motors, such as stator, rotor, and sensors, will also be explored.

2.2 Composition of Brushless Motor Control System

The brushless motor control system mainly consists of electronic commutators, sensors, control algorithms, and actuators. The electronic commutator is responsible for converting DC power into the AC power required by the motor, and controlling the operating status of the motor by controlling the current. Sensors are used to detect parameters such as the position and speed of the motor, in order to provide precise control to the control algorithm. The control algorithm determines the operating status and current control strategy of the motor based on feedback information provided by sensors. The actuator converts the control signal into the motion of the motor.

2.3 Overview of Control Strategy

The control strategies for brushless motors include two types: traditional control and intelligent control. Traditional control methods include PID control and fuzzy control, which are based on mathematical models and empirical rules to achieve stable operation of motors by adjusting control parameters. Intelligent control methods utilize artificial intelligence algorithms such as neural networks, genetic algorithms, and fuzzy logic to achieve more precise and adaptive control.

2.4 Traditional brushless motor control methods

The traditional control methods for brushless motors mainly include voltage source control and current source control.

2.4.1 Voltage source control

Voltage source control is one of the most common methods for brushless motor control. In voltage source control, the controller adjusts the power supply voltage of the motor to control its operating state based on the required speed and load conditions. Usually, voltage source control uses PWM (Pulse Width Modulation) technology to convert the voltage of the DC power supply into a pulse signal, and controls the motor speed and torque by adjusting the duty cycle of the pulse.

2.4.2 Current source control

Current source control is another common method of brushless motor control. In current source control, the controller controls the motor by controlling the phase current of the motor. The controller calculates the required phase current based on the speed and load conditions of the motor, and controls the magnitude and direction of the

phase current through an electronic commutator. Current source control has high dynamic response capability and can achieve more precise control.

These traditional brushless motor control methods have achieved widespread success in practical applications. However, traditional control methods may have some limitations under specific operating conditions, such as slow response to load changes and difficulty in achieving efficient operation. Therefore, for different application requirements, it is necessary to further optimize and improve traditional control methods, or adopt more advanced intelligent control algorithms to improve the performance of brushless motor control systems.

2.4.3 Requirements and challenges for brushless motor control system

The requirements and challenges of brushless motor control systems include high efficiency, high precision, high reliability, and low noise. Efficiency requires the motor to operate at optimal efficiency to reduce energy consumption. High precision requires motors to achieve precise speed and position control to meet various application requirements. High reliability requires the motor control system to operate stably and have fault detection and protection functions. Low noise requires that the noise generated during motor operation be controlled within an acceptable range.

3. APPLICATION OF INFORMATION TECHNOLOGY IN BRUSHLESS MOTOR CONTROL SYSTEM

3.1 Application of Sensor Technology in Brushless Motor Control

The sensor technology in the brushless motor control system is crucial for accurately detecting the position and speed of the motor, and is used to obtain relevant parameters of the motor's operating status, such as position, speed, and current.

3.1.1 Position Sensor:

Position sensors are used to accurately detect the position of motor rotors, and common position sensors include Hall sensors and photoelectric sensors. Hall sensors determine the position of the rotor by detecting changes in the magnetic field, while photoelectric sensors use the photoelectric effect to achieve position detection. These sensors feed back position information to the control algorithm to achieve accurate current control and commutation operations.

3.1.2 Speed sensor:

Speed sensors are used to measure the speed of motor rotors, and common speed sensors include photoelectric encoders and Hall encoders. These sensors calculate the actual speed of the rotor by detecting its rotation period and number of pulses. The feedback information provided by the speed sensor can be used for closed-loop control to ensure that the motor operates at the expected speed.

3.2 Application of Communication Technology in Brushless Motor Control

Communication technology plays an important role in brushless motor control, as it enables wireless communication and data transmission, providing more flexible and intelligent control methods for brushless motor control systems. The following are the applications of communication technology in brushless motor control:

3.2.1 Wireless control and monitoring:

Through wireless communication technology, remote control and monitoring of brushless motors can be achieved. The wireless communication module can be connected to the brushless motor controller, enabling remote start stop, speed adjustment, and parameter setting of the motor through wireless networks or Bluetooth technologies. Meanwhile, wireless communication can also be used for real-time monitoring of motor status and performance parameters, such as speed, temperature, current, etc., in order to adjust and optimize control strategies in a timely manner.

3.2.2 Communication bus control:

Communication bus technologies such as CAN (Controller Area Network) and Ethernet can be used for communication and coordination between multiple brushless motor controllers. By connecting multiple motor controllers to the communication bus, centralized control and collaborative work can be achieved, improving the coordination and consistency of the entire system. This is very important for multi motor systems or applications that require coordinated motion, such as robots, automated production lines, etc.

3.2.3 Data Interaction and Remote Monitoring:

Communication technology can enable data exchange and remote monitoring between brushless motor control systems and upper computers or cloud platforms. By connecting to the network, the control system can send real-time data and status information to the upper computer or cloud platform, achieving remote monitoring and fault diagnosis. At the same time, the upper computer can issue instructions and control parameters to achieve remote adjustment and optimization control.

3.2.4 Data Sharing and Collaborative Control:

Communication technology can achieve data sharing and collaborative control among multiple brushless motor control systems. Through communication networks, multiple motor controllers can exchange information and data in real-time, achieving collaborative work and distributed control. This is very important for applications that require multiple motors to collaborate to complete tasks, such as drones, electric vehicles, etc.

3.3 Application of Embedded Systems in Brushless Motor Control

Embedded systems play a crucial role in brushless motor control, integrating control algorithms, data acquisition, communication, and real-time execution functions to provide efficient and stable control and operation for brushless motor control systems.

The following are the applications of embedded systems in brushless motor control:

(1) Implementation of control algorithm:

Embedded systems are capable of embedding control algorithms and executing them in real-time. These control algorithms can make control decisions and adjust the driving signals and parameters of the motor based on sensor feedback data such as position, speed, and current. Embedded systems have high-performance processors and real-time operating systems, which can ensure the accuracy and responsiveness of control algorithms and achieve precise brushless motor control.

(2) Data collection and processing:

Embedded systems can integrate interfaces such as analog-to-digital converters (ADCs) for real-time acquisition and processing of sensor data. It can filter, calibrate, and preprocess the collected data to ensure the accuracy and stability of sensor data. Meanwhile, embedded systems can provide multiple communication interfaces, such as SPI, I2C, and UART, for data exchange with sensors, external devices, and communication modules. In addition, there are applications in real-time control and feedback, communication and remote control, system integration and reliability, etc., which will not be elaborated on one by one.

4. OPTIMIZATION STRATEGY

4.1 Model Predictive Control (MPC)

Model Predictive Control (MPC) is an advanced control strategy that has been widely applied in brushless motor control systems. MPC establishes a mathematical model of the motor, predicts its future behavior, and optimizes control based on the predicted results to achieve precise control of the motor system.

The basic idea of MPC is to predict the future behavior of the motor, including speed, torque, and current, by using the dynamic model of the motor during each control cycle. Then, based on the predicted results, the optimal control strategy is calculated through optimization algorithms and applied to the motor system. This prediction based

control method can make real-time adjustments and optimizations within each control cycle to adapt to different working conditions and control requirements.

The application of MPC in brushless motor control has the following advantages:

- (1) Multivariable control;
- (2) Constraint handling;
- (3) Robustness and adaptability;
- (4) Optimization of motion trajectory.

4.2 Intelligent Optimization Algorithm

Intelligent optimization algorithm refers to a type of algorithm based on computational intelligence and heuristic search, used to solve complex optimization problems. Intelligent optimization algorithms are widely used in parameter optimization, control strategy optimization, and performance optimization in brushless motor control systems. The commonly used intelligent optimization algorithms include genetic algorithm, particle swarm optimization algorithm, ant colony algorithm, artificial neural network, and ant colony particle swarm hybrid algorithm. Intelligent optimization algorithms have global search capability, adaptability, and powerful optimization ability, which can help optimize various problems in brushless motor control systems. By selecting appropriate optimization algorithms and objectives, the optimization and performance improvement of the motor system can be achieved. However, when applying intelligent optimization algorithms, parameter adjustments and algorithm improvements need to be made based on specific problems and system characteristics to achieve better optimization results.

4.3 Data driven approach

The data-driven approach is a modeling and control method based on measured data, which can achieve adaptive control and performance optimization. In brushless motor control, data-driven methods can learn the nonlinear characteristics and control laws of the motor through machine learning and deep learning techniques, and achieve accurate control and prediction. Common data-driven methods include data modeling and prediction, fault detection and diagnosis, data-driven optimization strategies, and data-driven fault prediction and maintenance. The data-driven approach has the advantage of fully utilizing actual operational data, which can better reflect the actual state and performance of the motor system. By analyzing and processing a large amount of data, motor control strategies can be optimized, fault detection and diagnosis can be achieved, and the operational efficiency and reliability of the system can be improved.

5. CASE ANALYSIS AND EXPERIMENTAL VERIFICATION

In this chapter, we will explore the application and optimization of information technology in brushless motor control systems through case analysis and experimental verification. We will select some typical application scenarios and analyze and validate them based on actual experimental data.

5.1 Case analysis

Firstly, we choose a brushless motor-driven robotic arm system as the case study for this article. The robotic arm needs to achieve precise position control and trajectory tracking to complete various tasks such as material handling, assembly operations, etc. We will design a brushless motor control system based on embedded systems and communication technology, and optimize it using model predictive control (MPC) and intelligent optimization algorithms.

We will provide a detailed description of the hardware and software architecture of the system, including embedded controllers, sensors, communication modules, etc. We will also introduce the application of communication technology in the system, such as using wireless communication modules to achieve data exchange and remote monitoring with the upper computer. In addition, we will use MPC algorithm to model and predict the motor system, and optimize the control strategy based on optimization objectives and constraints.

Through a detailed analysis of this case, we will demonstrate the application of information technology in brushless motor control systems and verify its effectiveness and advantages in practical scenarios.

5.2 Experimental verification

In order to verify the application and optimization effect of information technology in brushless motor control systems, we will conduct a series of experiments. In the experiment, we will conduct performance testing and comparative analysis based on the designed brushless motor control system through actual motor driving and data acquisition.

Specifically, we will conduct the following experimental content:

(1) Performance testing:

Test and evaluate the performance of the motor system by comparing different control strategies and parameter settings. We will analyze indicators such as speed response, torque output, and energy efficiency, and compare them with traditional control methods.

(2) Trajectory tracking experiment:

In the robotic arm system, we will conduct trajectory tracking experiments to verify the precise control capability of the designed control system for complex trajectories. We will record the error between the actual trajectory and the expected trajectory, and evaluate the tracking accuracy and stability of the control system.

(3) Fault detection and diagnosis experiment:

We will conduct fault detection and diagnosis experiments by introducing faults and abnormal situations, such as motor open circuits, short circuits, etc. We will analyze the system's ability to detect faults and diagnostic accuracy, and verify the effectiveness of the designed fault detection algorithm.

Through these experimental verifications, the experimental results will validate the advantages of the designed system in terms of performance, accuracy, and robustness, providing practical and feasible solutions for the application and optimization of brushless motor control systems.

6. DISCUSSION AND PROSPECT

6.1 Discussion

System reliability and safety: In brushless motor control systems, reliability and safety are very important considerations. We can discuss how to use information technology to improve the reliability and security of systems, including fault detection and diagnosis, fault-tolerant control, and protective measures.

Algorithm improvement and optimization: Although we have introduced some common information technology algorithms, there is still room for improvement and optimization. Discuss how to improve the Model Predictive Control (MPC) algorithm, such as using deep learning models to model and predict the behavior of motor systems. In addition, we can also explore how to combine multiple intelligent optimization algorithms to further improve the performance and efficiency of motor control systems.

Real time and responsiveness: Brushless motor control systems typically require real-time response and high-speed control. We can discuss how to use information technology to improve the real-time and responsiveness of the system, such as optimizing communication technology and embedded system design to reduce control latency and improve the real-time performance of the system.

6.2 Outlook

There are still many issues and challenges to be explored in the application and optimization of brushless motor control systems. In terms of prospects, the following directions are proposed:

(1) Hybrid intelligent algorithm:

Mixing different intelligent optimization algorithms and control strategies can further improve the performance and robustness of the system. For example, combining genetic algorithms and fuzzy control methods to optimize multiple parameters of a brushless motor control system.

(2) Human computer interaction and adaptive control:

With the development of artificial intelligence and machine learning, the application of human-computer interaction and adaptive control can be explored. By identifying and analyzing human behavior and intentions, a more intelligent and adaptive brushless motor control system can be achieved.

(3) Interdisciplinary Collaboration:

The application and optimization of brushless motor control systems require interdisciplinary cooperation, involving multiple fields such as electronic engineering, computer science, and control theory. In the future, cooperation and exchange between different disciplines can be strengthened to promote technological innovation and interdisciplinary research.

In short, the application and optimization of information technology in brushless motor control systems have broad development prospects. Through continuous research and innovation, we can further improve the performance, reliability, and efficiency of brushless motor control systems, and promote the development and application of brushless motor technology.

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