ELECTRICAL ENERGY LAB (EELAB)
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TOWARDS OPTIMAL EXPLOITATION OF ALL-ELECTRIC DUAL DRIVE POWERTRAINS IN SMART E-MOTION SYSTEMS

RESEARCH PROBLEM
Government institutions and industrial partners are aspiring green alternatives for contemporary transportation systems or industrial processes. All-electric drivetrains demonstrate interesting properties in this perspective, as direct harmful emissions in the atmosphere are eliminated. Optimal exploitation of the associated possibilities requires filling the gaps in state-of-the-art technology in terms of topology design, energy-efficient control strategies and supervisory power flow management agents.

OPTIMAL DESIGN OF AN ALL-ELECTRIC DUAL DRIVE

TIME-EFFICIENT SIZING OF BATTERY AND MOTORS
- Minimize computational time for design
- Minimize design and operational costs

GENETIC ALGORITHM

RATIONALE BEHIND DUAL DRIVE TOPOLOGY
- High speed
- High power
- No start/stop

OPTIMAL CONTROL STRATEGY

ENERGY-EFFICIENT REFERENCE TRACKING
- Energy-efficiency
- Accurate tracking
- Real-time execution
- Robustness

APPROXIMATE DYNAMIC PROGRAMMING

FPGA IMPLEMENTATION
- Parallelized calculations

PARAMETER ESTIMATION
- Model expectations
- Estimated parameters

OPTIMAL POWER FLOW MANAGEMENT

REAL-TIME DISTRIBUTION OF POWER DEMAND
- Provide discrete on/off commands to distinct motor drives
- Generate desired torque references for each separate motor
- Minimize consumed battery power $P_{bat}$

RESEARCH RESULTS
The conducted research aims at assembling some of the missing pieces to render all-electric drivetrains into a viable alternative of their contemporary combustion-based counterparts. Several aspects have been covered:

- DESIGN: Efficient modeling strategies combined with the utilization of an evolutionary algorithm allows to cut down the necessary optimization time by 96.9% when benchmarked against traditional approaches.
- CONTROL: The challenge to be tackled consists of optimizing both torque tracking and energy efficiency simultaneously. Dedicated approximate dynamic programming is able to reduce the overall cost by up to 57.5%.
- POWER FLOW MANAGEMENT: Employing automated regression techniques to cast the power dissipation of the subsystems into efficient dissipation models and subsequently plugging this into a supervisory dynamic programming agent provides range extensions of approximately 16%.

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