Branching Dueling Q-Network-Based Online Scheduling of a Microgrid With Distributed Energy Storage Systems

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Background

- Traditional online scheduling strategies are greatly affected by the accuracy of renewable energy and load forecasting.
- The discrete-action based DRL optimization methods (DQN, MuZero) are difficult to adapt for a microgrid with distributed BESSs.
- Develop the BDQ (Branching Dueling Q-Network) based optimization algorithm to learn to schedule the microgrid with multiple BESSs from historical load and renewable energy data without relying on any forecast information.

BDQ Based Online Optimization Strategy for Microgrid with Distributed BESSS

- Advantage: BDQ can achieve a linear increase in the number of neural network outputs with the number of distributed BESSs, which overcomes the curse of dimensionality caused by the charge and discharge decisions of multiple BESSs.
- The designed network architecture of the BDQ agent is given in the figure. The shared decision module consists of three LSTM units and a fully connected network. The LSTM units extract features from load power and renewable energy power sequences, then the extracted features concatenate with the current state of the microgrid and are then fed into a multilayer network. The features computed by the shared decision module are then used to compute the state value and the state-dependent action advantages on the subsequent independent branches.

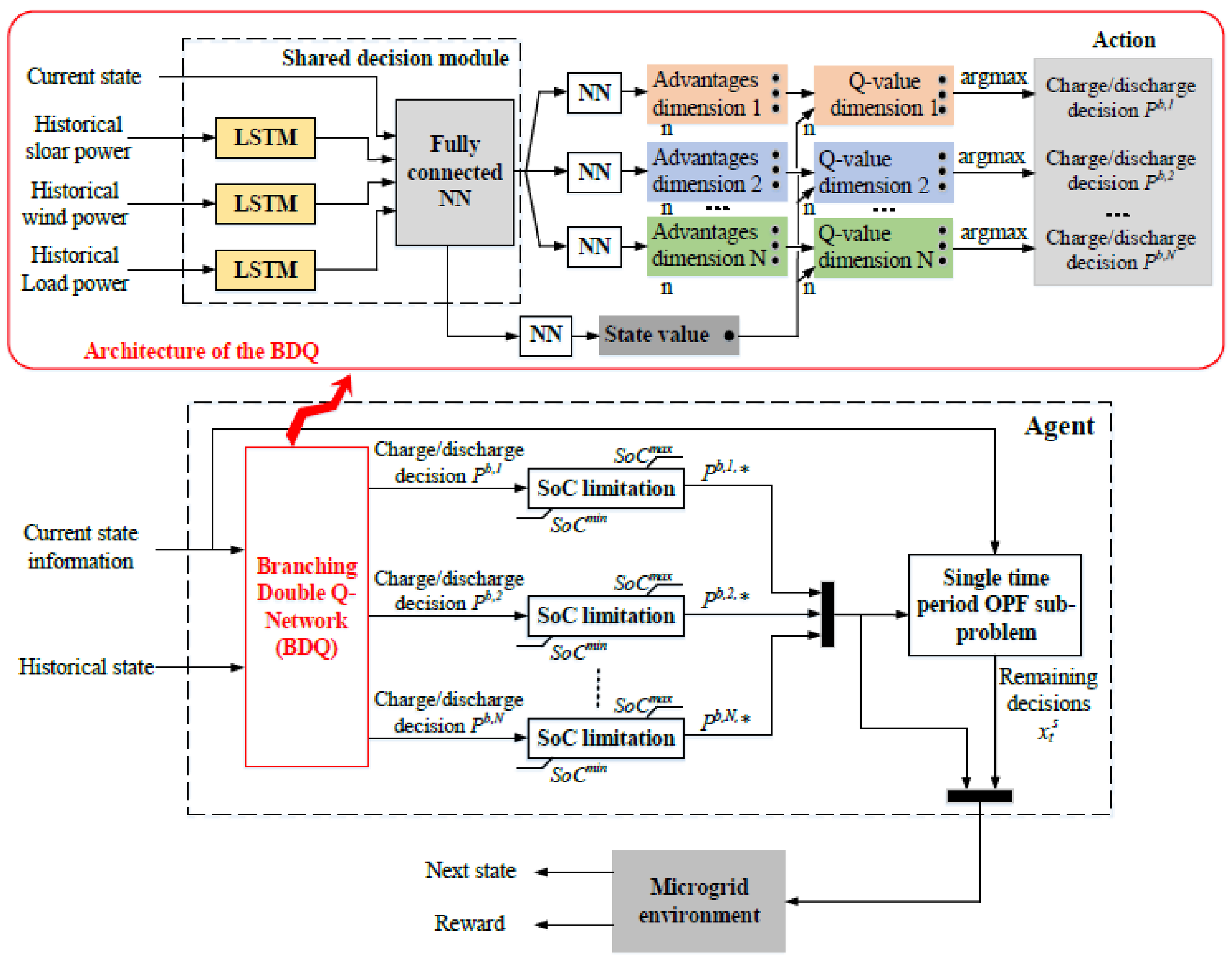

Fig. 1 The developed BDQ based online optimization strategy for a microgrid with distributed BESSs.

Case study

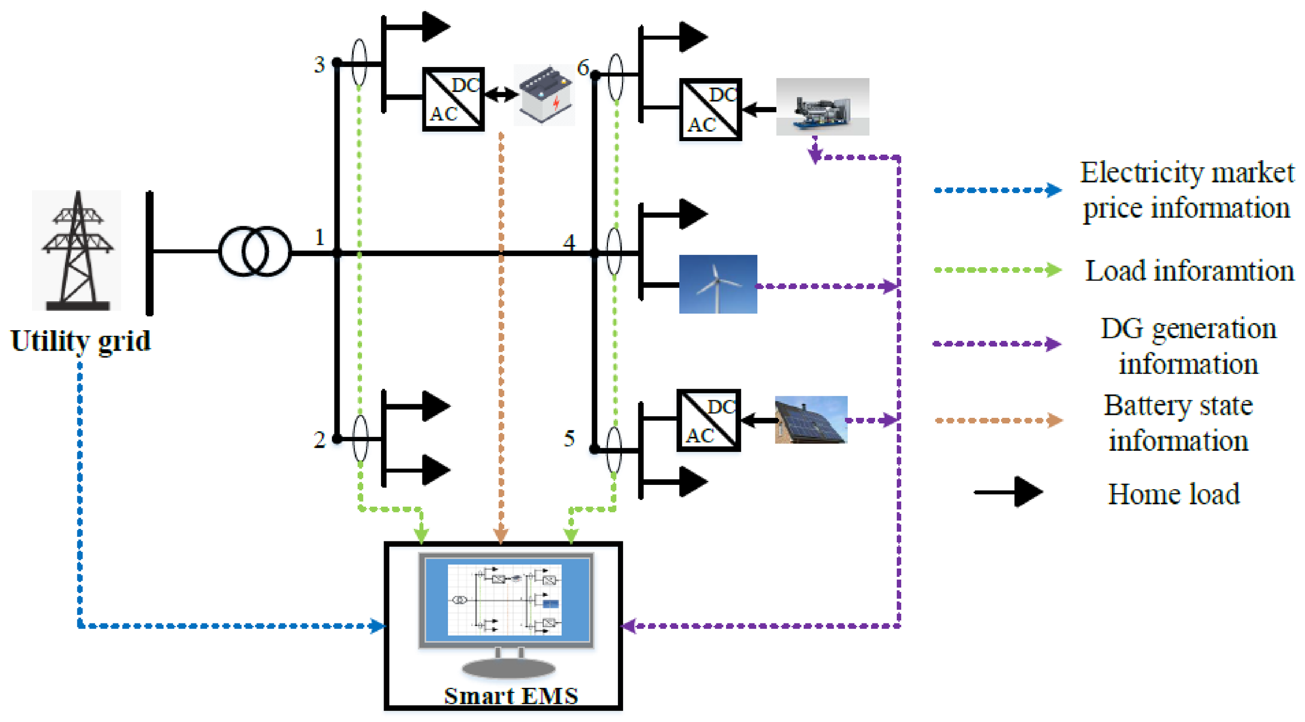

Fig. 2 The diagram of the 6-bus microgrid.

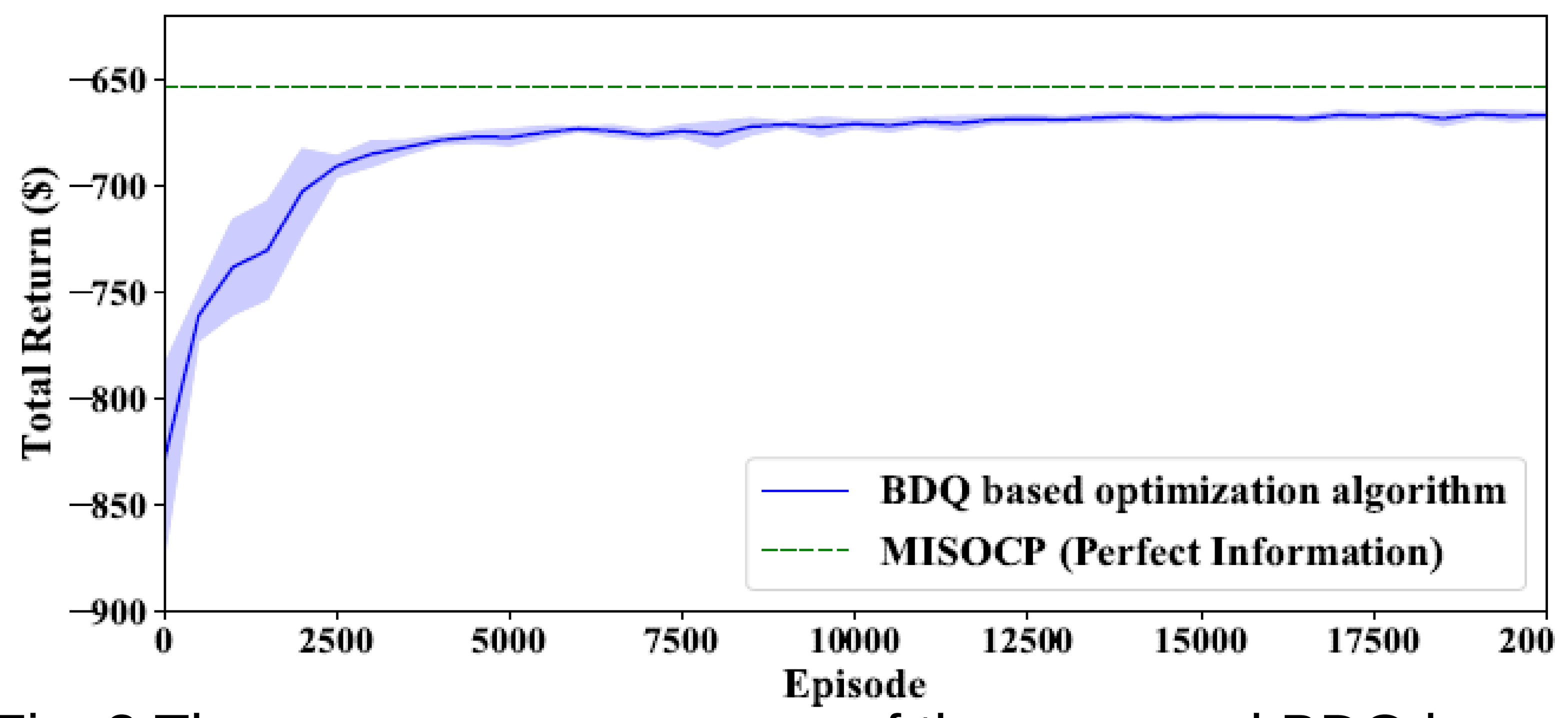

Fig. 3 The convergence process of the proposed BDQ based online optimization algorithm on the 6-bus microgrid system.

TABLE I
PERFORMANCE OF DIFFERENT METHODS COMPARED TO MYOPIC POLICY ON THE 100-DAY TESTING DATASET FOR THE 6-BUS MICROGRID.

Performance improvement		*Mean*	*Maximum*	*Minimum*	*Standard deviation*
Online methods	BDQ based optimization	8.52%	19.94%	3.19%	2.65%
	MuZero based optimization	9.30%	16.68%	5.28%	2.12%
	Lyapunov optimization	3.76%	9.89%	1.93%	1.65%
	ADP	6.57%	14.78%	4.16%	1.92%
	DDPG	5.55%	9.81%	-8.41%	4.16%
Off-line method	MISOCP (perfect information)	10.20%	23.28%	6.45%	3.02%

TABLE II
PERFORMANCE OF DIFFERENT METHODS COMPARED TO MYOPIC POLICY ON THE 100-DAY TESTING DATASET FOR THE IEEE 33-BUS MICROGRID.

Performance improvement		*Mean*	*Maximum*	*Minimum*	*Standard deviation*
Online methods	BDQ based optimization	7.48%	13.48%	4.26%	1.97%
	Lyapunov optimization	3.51%	6.88%	2.22%	1.08%
	DDPG	6.64%	15.27%	2.56%	2.82%
Off-line method	MISOCP (perfect information)	10.20%	23.40%	6.58%	2.98%

✓ Conclusion: The proposed BDQ based microgrid scheduling algorithm outperforms many state-of-the-art online scheduling strategies for microgrids in terms of optimization performance and time-consuming.