Table 3
Statistics on authors, powertrains, algorithms, and contributions of journal papers (Algorithm Innovation).

Author (Year)	Powertrain	Algorithm	Contribution
Du[173] (2019)	HETV	Fast Q Learning	Hardware-in-loop; KL divergence to trigger the update; cloud computation;
Han[174] (2019)	HETV	Double DQN	Longitudinal and lateral dynamic model; preventing the overestimated;
Li[175] (2019)	Power split HE Bus	DDPG	Integrating the terrain information; hybrid action space (engine and powertrain mode); dueling network; DP-based pre-training process;
Liu[176] (2019)	Power split PHEV	Dyna-H	Heuristic search and planning; model-free online RL algorithm;
Qi[177] (2019)	PHEV	Dueling DQN	The real-world traffic data to synthesize speed trajectories in Southern California; a new model type for the taxonomy of the EMS;
Tan[178] (2019)	PHE Bus	Actor-Critic	Serial parallel powertrain; avoid the discretization error and the dimensionality curse; robustness is verified;
Yin[179] (2019)	Mild HEV	PI	A stochastic model of the power demand;
Du[180] (2020)	HETV	Dyna-H DQN	The heuristic planning with the Dyna agent; the DQN-based EMS with the AMSgrad;
Guo[181] (2020)	PHE Bus	Q Learning	The optimal reference SOC trajectories as the expert experience; multiply driving cycle training method for the generalization performance; the RL-based agent is used to determine the co-state of the PMP-based EMS;
Guo[182] (2020)	HETV	DDPG	Transfer learning; a classification concept of speed with different intervals;
Lee[183] (2020)	Parallel HEV	Model-based RL	The transition probability of the driving speed profile;
Lee[184] (2020)	Parallel HEV	Q Learning	Comparative analysis between DDP, SPD, and RL; transfer learning;
Lian[185] (2020)	Power split HEV	DDPG	Embedding expert knowledge (the optimal brake-specific fuel consumption curve of the engine and the battery charge-discharge characteristics.);
Lian[186] (2020)	Power split HEV	DDPG	Transfer learning among four types of powertrains (Prius, power-split bus, series HEV, and series-parallel bus.);
Liu[187] (2020)	PHEV	Q Learning	In-vehicle learning; combining neuro-dynamic programming with future trip information; two-stage deployment strategy (short and long trips);
Xu[188] (2020)	Parallel HEV	Q Learning	Ensemble supervisory control (multiple RL agents make an action jointly);
Xu[189] (2020)	Parallel HEV	Q Learning	Parametric study: (1) state types and number of states, (2) states and action discretization, (3) exploration and exploitation, and (4) experience selection;
Du[190] (2021)	HETV	DQN	Heuristic experience replay; the adaptive moment estimation optimization with the Nesterov accelerated gradient NAG-Adam;
Lee[191] (2021)	FCV	Model-based RL	The data-driven update method by using the experience data alone;
Lee[192] (2021)	Parallel HEV	Q Learning	The equivalent factor of the ECMS-based EMS is determined by the RL agent;
Lee[193] (2021)	Multi-mode HEV	DQN	The co-state of the PMP-based EMS is determined by the DRL agent;
Lin[194] (2021)	PFCV	Q Learning	Online recursive algorithm using cosine similarity and a forgetting factor to update the transition probability matrix (TPM); hardware-in-loop;
Liu[195] (2021)	Power split HEV	TD3	A reward function with punishments for irrational actions;
Qi[196] (2021)	Power split PHEV	DQN	Self-supervised learning for the problem of sparse rewards; internal and external rewards;
Tang[197] (2021)	Parallel HEV	A3C DPPO	A3C-based and DPPO-based energy and emission management strategy; improving the learning efficiency in the multi-thread training process;
Xu[198] (2021)	Parallel HEV	Q Learning	Reducing the learning iterations by utilizing warm-start Q-value methods based on the ECMS-based EMS and heuristic control;
Yang[199] (2021)	Parallel HEV	Dyna	The Blended agent, Dyna, integrates direct and indirect RL; the queue-Dyna integrates backward focusing and prioritized sweeping; hardware-in-the-loop;

Author (Year)	Powertrain	Algorithm	Contribution
Yang[200] (2021)	Serial HEV	Q Learning	Indirect RL; high-order Markov chain for modeling the environment; an online recursive form of the TPM; The induced matrix norm is chosen to determine the time for updating the environment and triggering the recalculation;
Zhang[201] (2021)	PHEV	CADC	The constrained setting for training safety; the coach ensures the safe action from the actor; Lagrangian Relaxation for optimizing the MDP transform;
Zhang[202] (2021)	Parallel HEV	Double DQN	Facing variable driving cycles and introducing the distance traveled into the state space; solving the overestimation;
Zhou[203] (2021)	Parallel HEV	TD3	Heuristic rule-based local controller for eliminating irrational torque allocation; environmental disturbances; hybrid experience replay consisting of offline computed optimal experience and online learned experience;
Zhou[204] (2021)	PHEV	DDPG	An adaptive neuro-fuzzy inference system is built with the knowledge from DP; the DDPG and the ANFIS are combined to maximize the control utility; hardware-in-loop;
Zou[205] (2021)	Serial HEV	DQN	Normalized advantage function-based DQN; accelerated RL and an online-updated strategy; prioritized experience replay; MPC-DQN-based EMS; hardware-in-the-loop;
Biswas[206] (2022)	Multi-mode HEV	A3C PPO	Online updating framework; generating probable cycles using historical data;
Du[207] (2022)	HETV	Double DQN	Modified prioritized experience replay; adaptive optimization AMSgrad;
Hu[208] (2022)	Parallel HEV	DDPG	Deployment inefficiency, safety constraint, and simulation-to-real gap; hardware-in-the-loop; an offline cloud-based DRL framework;
Hu[209] (2022)	Parallel HEV	DDPG	The equivalent factor of ECMS-based EMS is determined by the DRL agent; The equivalent factor of ECMS-based EMS is determined by the DRL; a safe exploration relying on modifying by including the heuristic domain knowledge within the ECMS-based for the DRL agent; hardware-in-the-loop;
Li[210] (2022)	PHEV	SAC	The automatic entropy adjustment framework; the driving data collected from the real vehicle;
Li[211] (2022)	FCV	Q Learning	A speedy RL-based EMS by the pre-initialization; well-designed rules of power distribution are used to pre-initialize the Q-table; the fuel cell lifespan;
Lin[212] (2022)	PHEV	Q Learning	KL divergence rate to update the TPM of the demand power; an exploration factor balances explorations and learning;
Lv[213] (2022)	Parallel HEV	DQN	Inverse RL for obtaining the weight in the reward function for the battery and engine agents;
Maino[214] (2022)	Parallel HEV	Q Learning	The integrated modular software framework separately manages the dynamics of the agent, the environment, and the vehicle model;
Qi[215] (2022)	Power split HEV	DQN	Generalization ability; coding and decoding multiple states; KL-divergence is used to guide the training; an auxiliary agent and a correlation agent;
Qi[216] (2022)	Power split HEV	DQN	Hierarchical RL; transfer the optimal BSFC as the sub-goal, and avoid the 'blind' exploration by guiding to the direction of the sub-goal in the lower level;
Sun[217] (2022)	Parallel HEV	DQN	The DRL agent with an LSTM network that can retain historical information; deep recurrent reinforcement learning-based EMS;
Sun[218] (2022)	HETV	SAC	The Munchausen SAC-based EMS to bootstrap and improve optimization; prioritized experience replay; DP-based early assisted training sample;
Tang[219] (2022)	Parallel HEV	DDPG DQN	The multi-objective control aiming at the engine and gearbox; combined with the learning-based EMS and rule-based engine start-stop strategy; RL is not suitable for learning intermittent strategies;
Wang[220] (2022)	Power split HE Bus	DDPG	The softmax deep double deterministic policy gradients algorithm; an action masking technique for preventing invalid actions; transfer learning;
Xu[221] (2022)	Parallel HEV	Q Learning	double Q-learning network, Boltzmann softmax, and dual-actor; The adaptability interpretation: driving cycle, vehicle load condition, and road grade;
Xu[222] (2022)	Power split HEV	Dueling DDPG	Transfer learning; the adaptive parameter space noise to balance exploration and exploitation which is better than the action space noise; a novel real-time four-phase approach: modeling, pre-training, transferring, fine-tuning;

Author (Year)	Powertrain	Algorithm	Contribution
Yang[223] (2022)	Serial HEV	Q Learning	An online recursive Markov Chain for depicting the stochastic environment; a pre-trained Q-table is employed as a heuristic function to guide the search;
Zhang[224] (2022)	HETV	DDPG	Prioritized experience replay; an online updating framework; The TPM; the KL divergence; new training is triggered by reaching a predetermined length;
Zhou[225] (2022)	Parallel HEV	A3C	N-step batched advantage function estimation and entropy regularization; random network distillation and inverse dynamics model is formulated as intrinsic exploration bonus (so-called curiosity-inspired);
Zhou[226] (2022)	Power split HEV	Q Learning	An RL-based EMS is proposed and compared with the PID-based EMS;
Matteo[227] (2023)	Parallel HEV	DQN DDPG	Two distinct reward functions: (1) SOC-oriented EMS guaranteeing a charge-sustaining whilst reducing the fuel consumption; (2) Fuel-oriented EMS minimizing the fuel consumption whilst ensuring a SOC by the end;
Bo[228] (2023)	Serial HEV	SARSA	TPM of the power demand; the forgetting factor, KL divergence rate threshold value, and TPM updating interval to determine the update of the strategy;
Guo[229] (2023)	FCV	REINFORCE	Fuzzy REINFORCE; approximating the policy function with a fuzzy inference system; a fuzzy baseline function is adopted to approximate the value function; hardware-in-Loop;
Hu[230] (2023)	Parallel HEV	DDPG	Heuristic domain knowledge; uncertainty-aware model-based offline RL; conservative Markov decision processes; hardware-in-the-loop;
Hu[231] (2023)	Parallel HEV	TD3	A hybrid strategy combining data-driven-based RL (PID-based AECMS) and simulation-based RL from the real logging data and simulated simple model; behavior cloning; a deep inverse dynamics model to decide which action is suitable; hardware-in-the-loop;
Hu[232] (2023)	Serial HE Bus Power split HEV	DDPG TD3	Serial parallel powertrain; The DP-based expert demonstrations model for guiding DRL agents as apprenticeship-RL; the domain adaptive meta-learning is used to train the expert demonstrations model; adversarial training was used to adapt the different driving conditions;
Hu[233] (2023)	Parallel HEV	TD3	DRL-based supplementary learning controller for a rule-based EMS; ape-X distributed architecture for improving the converging speed; the gap between simulation and real application; feasible and acceptable EMS; The actor in the vehicle and the learning in the cloud;
Hua[234] (2023)	Multi-mod e HEV	DDPG	Multi-agent DRL; a hand-shaking strategy is proposed to enable two agents to work collaboratively by introducing a relevance ratio;
Huang[235] (2023)	FC Bus	TD3	Prioritized experience replay; a stochastic training environment is established with real-world data; a DP-based pre-training method;
Huang[236] (2023)	FCV	DDPG	Taking fuel cells as range extenders; previous action guidance mechanism by introducing previous actions into the reward function; Dual DDPG-based EMS for the pure electric mode and range extend mode;
Li[237] (2023)	FC Bus	TD3	Limiting the battery aging and fuel cell power variation; real-world collected driving conditions;
Liu[238] (2023)	Power split PHEV	Q Learning	A state-space merging both SOC and travel distance to shrink the state-action space; DP-based imitation learning procedure in the RL training process;
Liu[239] (2023)	Power split HEV	DPPO	Physical constraints and training safety; reward-directed policy optimization adopts exterior point method and curriculum learning to direct the agent to recognize and avoid irrational control signals and optimize the fuel economy;
Mousa[240] (2023)	Parallel PHEV	DQN	Integrating the RL into the rule-based hybrid control unit with a limited domain; minimizing the fuel consumption and the engine on/off switching; the extended-DQN combing networks, DDQN with soft update, N-steps bootstrapping, and action masking;
Ruan[241] (2023)	Multi-mod e HEV	DDPG	DRL-based-EMS in the charge-depletion stage and the regenerative braking mode; discrete-continuous hybrid actions space;
Wang[242] (2023)	Parallel PHEV	13 DRL algorithms	The code is available on GitHub; a unified performance review benchmark; 13 popular DRL-based EMSs are compared; The reward performance, computation cost, and learning convergence are discussed;
Wu[243] (2023)	Multi-mod e PHEV	TD3	The Gumbel-Softmax in the actor-network realizes mode selection and torque distribution; hybrid action space; a rule-based mode control mechanism to eliminate unreasonable exploration;

Author (Year)	Powertrain	Algorithm	Contribution
Yan[244] (2023)	Parallel HEV	TD3	A non-weight reward function; state space refinement for coping the state redundancy; battery health about the consciousness of lithium-ion battery;
Yang[245] (2023)	Serial HEV	Nash QL	Multi-Agent Reinforcement Learning combines game theory and reinforcement learning; engine-generator set (Agent 1), battery and supercapacitor (Agent 2); fuel economy, SOC and health of batteries and SOC of supercapacitor; the Nash equilibrium of multiple objectives;
Yang[246] (2023)	Serial HEV	Dyna	Various driving scenarios; online-learning adaptive EMS; the real precious experience is used to train the policy and establish an interactive model; realizing the rapid and low-cost online learning;

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