

grate the rotatable STAR-RIS into MEC systems [14]. For example, although RIS configurations have been intensively studied, existing algorithms are not suitable of the optimization of STAR-RIS configurations since they must be designed based on different operating protocols, namely energy splitting (ES), mode switching (MS), and time switching (TS) [9]. Meanwhile, STAR-RIS introduces more adjustable parameters beyond phase shift, i.e., the amplitude coefficients for ES/MS protocol, and time allocation for TS protocol, all of which are highly coupled with STAR-RIS orientation and computation resource allocation for MEC [15]. In addition, although existing studies have explored the orientation optimization of RIS/STAR-RIS, most of them focus on static- or single-UD environments [16], [17], which may not fully capture the complexities arising from multiple moving UD in MEC systems. Therefore, this paper proposes a rotatable STAR-RIS scheme to account for dynamic environments and enhance MEC performance. The primary contributions of this paper are outlined as follows.

- We propose a novel rotatable STAR-RIS-assisted MEC system with multiple moving UDs, where the STAR-RIS can dynamically adjust its orientation to accommodate UDs mobility. Considering the characteristics of STAR-RIS, the energy consumption minimization problem is formulated for three operating protocols, jointly optimizing STAR-RIS configurations, orientation, computation resource allocation, transmission power, and task offloading strategies.
- To account for practical scenarios, we incorporate discrete phase shift, STAR-RIS elements grouping, and UDs mobility into our model. Thus, the energy consumption minimization problem is formulated as a time-vary problem. Considering this problem is difficult to handle using traditional algorithms, we propose a sample-efficient deep reinforcement learning (DRL) algorithm based on soft actor-critic (SAC) to adapt to the dynamic environment and achieve near-optimal solutions.
- Simulation results validate that the proposed approach outperforms representative DRL algorithms in both convergence and performance. Additionally, the proposed rotatable STAR-RIS scheme significantly reduces energy consumption compared to the fixed scheme.

The rest of the paper is structured as follows. Related works are discussed in Section II. In Section III, the system model and formulated energy consumption minimization problems are presented. In Section IV, we detail the proposed solution algorithms. In Section V, performance evaluation is conducted to demonstrate the validation of our proposed system. Finally, Section VI concludes this paper.

Notation: Throughout this paper, non-boldface, boldface lowercase, and boldface uppercase letters denote scalar, vector, and matrix, respectively; $|\cdot|$, $\|\cdot\|_2$, and $(\cdot)^H$ denote absolute value, ℓ_2 -norm, respectively; $\mathbb{E}(\cdot)$, $\text{diag}(\mathbf{a})$, $\mathcal{CN}(0, \sigma^2)$ represent expectation, a diagonal matrix with vector \mathbf{a} on the main diagonal, and complex Gaussian distribution with zero mean value and variance σ^2 , respectively.

II. RELATED WORKS

1) *MEC:* In recent years, MEC technologies have garnered significant attention from academic researchers and been applied in various domains [18]. By provisioning extensive computation resource at edge, MEC facilitates low-latency wireless access, thereby enabling lightweight terminals with limited processing capability to efficiently handle computing-intensive tasks. Furthermore, researchers have conducted in-depth optimizations of MEC systems with diverse objectives. For example, [19] proposed a wireless powered MEC system featuring binary computation offloading, utilizing block coordinate descent (BCD) and alternating direction method of multipliers to maximize computation rate by optimizing the selection of computing mode and allocation of transmission time. In scenarios where UDs are highly sensitive to latency, [20] focused on weighted total latency minimization and proposed an innovative approach jointly designing communication, computation, and caching configurations in MEC systems. To improve task execution efficiency, [21] investigated the energy efficiency maximization problem for task offloading in a two-tier MEC network. Nevertheless, the aforementioned studies mainly concentrate on task offloading for fixed UDs, which may limit their applicability in practical scenarios. To address this, [22] introduced a mobility-aware MEC network and employed reinforcement learning (RL) to jointly optimize task offloading and migration schemes aiming to maximize system revenue. Additionally, to further extend MEC network coverage and improve deployment flexibility, [23] incorporated unmanned aerial vehicles (UAVs) into MEC systems to maximize computation rate.

2) *RIS and STAR-RIS:* Thanks to its advantageous features, RIS has garnered substantial attention from both industry and academia. For example, [24] jointly designed phase shifts, offloading strategies, and transmission power based on BCD and Lagrange multiplier method to minimize weighted total latency. To further ensure task offloading security, [25] proposed a RIS-assisted MEC system framework, and investigated the problem of maximizing the minimum computation efficiency, optimizing local computation frequencies, IoT devices' transmission power and RIS phase shifts to meet secure computation rate demands. For moving UDs, [26] aimed to minimize energy consumption through jointly designing RIS phase shifts and UDs' transmission power.

Despite these appealing features of RIS, the spatial restriction of transmitters and receivers imposes challenges in practical implementation, prompting the development of STAR-RIS [9], [10]. Currently, the study of STAR-RIS is still in its early stages. In [27], Xu *et al.* proposed the STAR-RIS concept, introducing standard hardware and channel models covering both near-field and far-field scenarios. Then, the operating protocols of STAR-RIS were further investigated in [10], analyzing the constraints, merit, and demerit of each protocol. Furthermore, in [28], STAR-RIS was introduced into MEC systems, where the STAR-RIS was operated under the TS protocol, with the objective of minimizing the total energy consumption of UDs, involving the joint optimization of STAR-RIS transmission/reflection time and coefficients.