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A Survey on Optimization of Federated Learning Based on Edge-Cloud Collaboration

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Abstract:

In order to address issues including resource limitations, data heterogeneity, and computational inefficiency, this study explores the optimization of lightweight federated learning (FL) in edge-cloud collaborative contexts. Due to non-IID data distributions, high communication costs, and restricted device capabilities, traditional federated learning frameworks perform below expectations in edge environments. This study analyzes the background and challenges, elaborates on definitions and theories, emphasizes the classification of federated learning and finally provides several optimization solutions. The objective is to provide strong support for federated learning applications in resource-constrained scenarios while efficiently increasing the operational efficiency of federated learning systems in edge-cloud environments. The results lay the groundwork for future studies on scalable and effective distributed learning systems by highlighting the promise of lightweight FL in applications like smart healthcare and industrial Internet of Things (IoT). In particular, it underscores the need for adaptive mechanisms that dynamically adjust computation and communication strategies based on the capabilities of edge devices.

Keywords: Edge-cloud collaboration; Federated learning; Communication protocols; Optimization Methods.

1. Introduction

Due to the rapid proliferation of Internet of Things (IoT) devices and the extensive integration of artificial intelligence technology, worldwide data generation is increasing at an annual rate above 30%. By 2025, the global count of IoT devices will surpass 41.6 billion, while the market valuation of edge computing will attain $274 billion. The necessity for real-time data processing in fields including intelligent transportation, industrial automation, and smart cities is becoming progressively critical. Federated learning (FL), an innovative paradigm of distributed machine learning, has attracted considerable attention and widespread application in fields such as edge computing and deep learning. By enabling collaborative