HypeFL: A Novel Blockchain-Based Architecture Using Federated Learning and Cooperative Perception for a Fully-Connected Autonomous Vehicle System

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According to the World Health Organization, road traffic crashes cause up to 50 million preventable injuries worldwide each year. Connected autonomous vehicles have been proposed as a solution, involving centralized machine learning (ML)-based frameworks that collect mass amounts of data on central servers for training. Unfortunately, these systems expose private data, threaten vehicle security, and lack collective intelligence between vehicles. Therefore, we propose HypeFL, a novel framework built on Hyperledger Fabric that combines blockchain and ML to create a decentralized, collaborative, fully-connected autonomous vehicle system. HypeFL enables cooperative perception, where vehicles fuse road perceptions to collaboratively perceive their environments and ensure optimal driving decisions. Our system utilizes federated learning, a distributed ML approach, to optimize data privacy by only sharing model parameters between vehicles, rather than raw data. The blockchain provides an immutable, decentralized server that stores model parameters and vehicles as nodes, which provides protection against single-point failures, eliminates the risk of malicious attacks, and emphasizes data privacy through a novel consensus protocol based on the Multi-Krum algorithm. We tested HypeFL in real-world conditions using the online CARLA simulator, recording an average object detection accuracy of 93.1% with a 35% decrease in collision rate compared to current approaches. We then generalized HypeFL to a physical environment with miniature Raspberry Pi-powered cars, observing a 71.7% decrease in collision rate. HypeFL creates a framework for fully autonomous vehicles with the potential to revolutionize transportation, improve safety for all drivers, and save countless lives.

Awards Won:
Third Award of $1,000