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Abstract

Real-Time Video Analytics Empowered by Machine Learning and Edge Computing for Smart Transportation Applications

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Traffic cameras have the properties of being cost-effective, information-rich, and widely deployed, which are filling up a big gap in today's traffic sensor needs. With the recent progress in traffic operations, information technology, and computer vision, traffic video analytics is driving a broad range of smart city applications with great potential to benefit future transportation and infrastructure systems. Most such applications, e.g., smart traffic surveillance and autonomous driving, require not only high intelligence but also real-time processing capability. Real-time video analytics is well-believed to be one of the most challenging yet most powerful applications for smart cities. It is often bottlenecked by the large volume of video data, high computational cost, and limited data communication bandwidth.

This dissertation explores general guidelines and new traffic video analytical methods and systems towards high intelligence and real-time operations for roadway transportation. The designs focus on both the algorithm level and the application system level. On the one hand, lightweight methods are devised based on machine learning techniques and transportation domain knowledge for high smartness, accuracy, and efficiency in specific traffic scenarios. On the other hand, system architectures are developed by leveraging the power of edge computing so that we can split the computational workload between the centralized servers and local Internet-of-Things (IoT) devices for the purpose of system performance optimization.

The traffic analytics products and findings in this dissertation can be applied to three transportation-related scenarios with different properties regarding video data collection and processing: (1) traffic surveillance, (2) vehicle onboard sensing, and (3) unmanned aerial vehicle (UAV) sensing. Correspondingly, they apply to three key components of modern intelligent transportation systems (ITS), i.e., smart infrastructures, intelligent vehicle, and aerial surveillance for road traffic. These components possess unique characteristics that can be utilized for video analytics, yet with different challenges to address. To this end, the dissertation proposes algorithms, frameworks, and field implementation examples of how to design and evaluate traffic video analytics systems for smart transportation applications towards high intelligence and efficiency. Experiments were conducted with real-world datasets and tests in a variety of scenarios. This dissertation is among the first efforts in developing edge computing applications for transportation and in exploring UAV sensing for traffic flow.