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A03 Case Study Analysis on Edge-Computing Video Analytics for Real-Time Traffic Monitoring in a Smart City

Introduction:

The Liverpool Smart Pedestrians project represents a pioneering initiative in urban traffic monitoring and smart city development. Initiated in February 2018 as a collaboration between the Liverpool city council and the University of Wollongong, this project aimed to develop innovative solutions for non-intrusive data collection to support urban planning in Liverpool, New South Wales. The project addresses critical challenges in modern urban environments, particularly the need for accurate, privacy-compliant traffic monitoring systems that can leverage existing infrastructure while providing real-time insights for city planning.

Discussion:

The methodology of the project was carefully designed through extensive community engagement, including two workshop sessions that helped define the core requirements. The project team identified three primary objectives: implementing multi-modal detection and tracking capabilities for pedestrians, vehicles, and cyclists; ensuring privacy compliance in data collection; and maximizing the use of existing infrastructure, particularly the CCTV network. These requirements guided the development of an edge-computing solution that could process video feeds locally while maintaining data privacy. The technical implementation centered on the NVIDIA Jetson TX2 platform, chosen for its powerful computing capabilities and energy efficiency. The system employs the YOLO V3 algorithm for object detection, coupled with the SORT tracking algorithm, enabling real-time detection and tracking of multiple objects. This edge-computing approach processes data directly on the device, transmitting only meta-data rather than raw video feeds, thereby addressing both privacy concerns and bandwidth limitations. The validation experiments demonstrated promising results, with the system achieving a mean accuracy of 69% in pedestrian detection while maintaining real-time processing capabilities at approximately 20 frames per second. The system showed particular strength in tracking smaller groups, though accuracy decreased somewhat with larger crowds due to occlusion challenges. These results validate the feasibility of using edge-computing solutions for urban monitoring applications.

The real-world applications of the system were tested in two distinct scenarios. The indoor deployment during an emergency evacuation demonstrated the system's capability to monitor crowd movements effectively, providing valuable insights into building evacuation patterns. The outdoor deployment in Liverpool's city center, comprising 20 sensors, showcased the system's ability to monitor traffic patterns continuously across different environmental conditions. These deployments provided urban planners with unprecedented access to real-time mobility data. The project encountered several technical challenges, primarily related to environmental factors affecting detection accuracy and the optimization of power consumption. The development team addressed these through adaptive processing algorithms and energy-efficient hardware configurations. Future improvements could include implementing more sophisticated GPU-accelerated tracking algorithms and exploring hybrid edge-cloud architectures for enhanced functionality.

Since the project's inception in 2019, significant advancements in edge computing hardware and AI algorithms have emerged that could enhance system performance. These include more efficient neural network architectures, improved object detection algorithms, and more powerful edge computing platforms like the NVIDIA Xavier, which offers enhanced processing capabilities for similar applications.

Conclusion:

The Liverpool Smart Pedestrians project demonstrates a successful implementation of edge computing technology for urban monitoring applications. The solution effectively balances the need for accurate traffic monitoring with privacy concerns and infrastructure limitations. The project's outcomes provide valuable insights for future smart city initiatives, particularly in the development of privacy-aware monitoring systems. As cities continue to grow and evolve, the methodologies and technologies developed through this project offer a framework for implementing intelligent urban monitoring solutions that support data-driven city planning while respecting citizen privacy.

Resources:

Bathelemy, Johan, et. al. (2019, February 28). Edge-Computing Video Analytics for Real-Time Traffic Monitoring in a Smart City.

Badidi, Elarbi, et. al. (2023, January). Opportunities, Applications, and Challenges of Edge-AI Enabled Video Analytics in Smart Cities: A Systematic Review. <https://www.researchgate.net/publication/372835650_Opportunities_Applications_and_Challenges_of_Edge-AI_Enabled_Video_Analytics_in_Smart_Cities_A_Systematic_Review>.