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**A03 Case Study Analysis**

**Edge-Computing Video Analytics for Real-Time Traffic Monitoring in a Smart City: Analysis Report**

**Introduction**

The Liverpool Smart Pedestrians Project was launched to address urban planning challenges related to traffic congestion, pedestrian flow, and sustainability in Liverpool, Australia. The project aimed to develop a real-time, privacy-compliant traffic monitoring system utilizing edge-computing video analytics. By leveraging existing CCTV infrastructure, the project sought to provide real-time, data-driven insights for urban planning without compromising privacy regulations.

**Methodology**

The project adopted an edge-computing approach, enabling real-time data processing at the sensor level. The methodology included:

* Community Workshops to identify key requirements for the system.
* Development of an Edge-Computing Sensor using the NVIDIA Jetson TX2 for on-device processing.
* Integration of YOLO V3 for real-time object detection and SORT tracking algorithm to monitor pedestrian and vehicle movement.
* Data Transmission via LoRaWAN or Ethernet, ensuring scalability and privacy compliance. The edge-based processing minimized bandwidth usage and safeguarded privacy by transmitting only metadata rather than raw video footage.

**Technology and Implementation**

The system’s core hardware and software components included:

* NVIDIA Jetson TX2: An embedded GPU platform optimized for deep learning inference.
* YOLO V3 Algorithm: A state-of-the-art object detection model, chosen for its balance between speed and accuracy.
* SORT Algorithm: A tracking system that uses a Kalman filter and Hungarian algorithm for real-time multi-object tracking.
* Agnosticity Infrastructure: A RESTful API-based framework enabling interoperability between different sensors and communication protocols.

The use of edge computing reduced data transmission costs, improved privacy, and allowed for real-time analysis without overwhelming the cloud infrastructure.

**Validation and Performance**

The validation experiments assessed accuracy, speed, and system utilization using the Oxford Town Center Dataset. Key findings include:

* Mean detection accuracy of 69%, with a tendency to underestimate crowded pedestrian environments.
* Real-time processing at 19.57 FPS, though performance fluctuated based on object density.
* Resource Utilization: The Jetson TX2 GPU was occasionally underutilized due to CPU-bound tracking computations, highlighting the need for further optimization.

Overall, the system demonstrated high efficiency in low-to-moderate traffic conditions but faced minor performance drops in high-density areas due to occlusion and computational bottlenecks.

**Real-World Applications**

The Liverpool Smart Pedestrians Project deployed 20 sensors in real-world environments, with two key case studies:

1. Indoor Deployment: The system successfully monitored pedestrian evacuation patterns, providing insights into emergency response effectiveness.
2. Outdoor Deployment: Sensors tracked daily traffic trends, revealing peak pedestrian activity between 8 AM - 4 PM and distinct vehicle flow patterns.

The project showcased the feasibility of real-time urban analytics, benefiting smart city initiatives.

**Challenges and Future Work**

Challenges identified in the study include:

* Tracking accuracy limitations in high-density areas due to occlusions.
* CPU-bound tracking algorithms limiting real-time efficiency.
* Scalability concerns, as expanding beyond 20 sensors would require further optimization.

Future improvements include:

* Adopting the NVIDIA Xavier platform, which offers double the computational power.
* Optimizing tracking algorithms for GPU acceleration to reduce CPU bottlenecks.
* Exploring newer deep learning models like YOLOv5 or Transformer-based architectures for enhanced accuracy.
* Enhancing interoperability with more IoT frameworks to support additional smart city applications.

**Personal Evaluation**

The Liverpool Smart Pedestrians Project effectively demonstrated how edge-computing video analytics can enhance urban planning. By minimizing bandwidth usage, ensuring privacy compliance, and leveraging existing CCTV infrastructure, the project provided a cost-effective and scalable solution for real-time traffic monitoring.

However, improvements in tracking accuracy, computational efficiency, and AI model selection could further enhance system performance. Future advancements in edge AI, 5G communication, and advanced deep learning algorithms could significantly improve similar projects worldwide.

Overall, the project is a strong step toward smarter, data-driven urban planning, and with continued refinements, it could serve as a blueprint for future smart city initiatives.

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