**Liverpool Smart Pedestrians Project: An Overview**

The **Liverpool Smart Pedestrians Project** was part of the Australian Government's **Smart Cities and Suburbs Program**. The main objective of the project was to develop a non-intrusive traffic monitoring solution for urban planning in Liverpool, which is a rapidly growing area. The system aimed to track multi-modal transportation—pedestrians, cyclists, and vehicles—while ensuring privacy compliance in real time. By leveraging the city's existing CCTV infrastructure, the project aimed to reduce costs while improving traffic management and urban planning.

Liverpool's city center is experiencing increased pedestrian traffic due to redevelopment initiatives. With rapid urbanization, the city anticipates a rise in traffic flow. The smart pedestrian system aims to address the following challenges:

* Managing the increasing traffic flow due to urbanization.
* Integrating new technology for data collection and traffic monitoring.
* Ensuring privacy compliance amidst growing surveillance.
* Scaling and adapting the system as the city continues to grow.

The use of existing CCTV infrastructure helps avoid large-scale investments in new infrastructure, making the solution cost-effective while supporting better urban planning practices.

### **Methodology**

The project employed a **community-driven methodology**, including two community workshops where local participants provided valuable feedback. This feedback helped shape the requirements for the traffic monitoring system. These requirements included:

* **Multi-modal detection**: The sensor needed to detect and track various types of transportation, including pedestrians, cyclists, and vehicles.
* **Privacy compliance**: The system had to ensure that no personal data was collected or stored, complying with strict privacy regulations.
* **Leveraging existing infrastructure**: The solution needed to work with the city’s existing CCTV network, avoiding costly new infrastructure investments.
* **Scalability and interoperability**: The system had to be scalable, allowing for easy integration of additional sensors as the city grew.

Based on these requirements, the smart visual sensor was designed to operate on the **edge-computing paradigm**, using computer vision and deep neural networks to process video data locally. This eliminates the need to send raw footage to a central server, ensuring privacy.

### **Technology and Implementation**

The hardware selected for the sensor was the **NVIDIA Jetson TX2**, a powerful computing platform designed for real-time AI applications. This device is capable of performing high-performance tasks, such as detecting objects using deep learning algorithms.

The software chosen for object detection was **YOLO v3** (You Only Look Once), a state-of-the-art object detection algorithm known for its speed and accuracy. YOLO v3 enables real-time detection and tracking of various objects in video footage.

**Edge computing** played a central role in this project, enabling the sensor to process data locally rather than transmitting it to a cloud server. The advantages of edge computing include:

* **Reduced latency**: Real-time decision-making without delays.
* **Privacy compliance**: Data is processed locally without transmitting raw footage, ensuring compliance with privacy regulations.
* **Cost efficiency**: By leveraging existing CCTV infrastructure, the need for additional storage and computing resources is reduced.

### **Validation and Performance**

The performance of the sensor was evaluated based on key metrics:

* **Accuracy**: The sensor was able to accurately track objects it was tasked to detect.
* **Speed**: The sensor was capable of processing real-time data without delays, even when handling high volumes of traffic.
* **System utilization**: Metrics related to CPU usage, power consumption, and memory utilization were monitored to ensure the sensor was functioning efficiently.

Validation experiments showed that the sensor was able to track objects with **71% accuracy** at a rate of **4 frames per second**, demonstrating the effectiveness of deep learning techniques for object detection in real-time environments.

### **Real-World Applications**

The sensor was deployed in two real-world applications:

1. **Indoor Emergency Evacuation**: The sensor was tested in an indoor environment to monitor traffic flow during an emergency evacuation. It provided critical data to help improve safety measures and adapt to dynamic crowd movements.
2. **Outdoor Deployment in Liverpool**: The sensor was deployed in the city of Liverpool to monitor pedestrian, vehicle, and cyclist traffic. The goal was to assess the sensor's ability to handle complex data and support urban planning by providing valuable real-time data for traffic management.

Both applications demonstrated the effectiveness of the sensor in enhancing urban planning. The ability to process real-time data using **edge gateways** allowed for immediate adjustments in traffic management, contributing to safer environments, especially during emergencies.

### **Challenges and Future Work**

Several challenges were encountered during the project:

* **Privacy compliance**: Ensuring the protection of sensitive data was a constant challenge, especially in large-scale deployments.
* **Data quality and resolution**: Weather conditions could affect image quality, which impacted the accuracy of object detection. One potential improvement could be the use of more advanced neural networks, such as **R-CNN**, to enhance performance under adverse conditions.
* **Scalability**: As the number of sensors and data sources grows, ensuring the system runs smoothly at scale remains a challenge.

**Future Work** could focus on:

* **Algorithm improvements**: Advancing object detection algorithms for better accuracy and robustness in various conditions.
* **Sensor network expansion**: As cities grow, expanding the network of sensors and integrating other types of data could further enhance the system's capabilities.
* **Integration with other smart city technologies**: Connecting the system to other smart city initiatives could improve the overall responsiveness of the urban environment.

### **Technological Developments Since 2019**

Since the conclusion of the project in 2019, several technological advancements could significantly improve the deployment and performance of similar smart city projects. These include:

* **Advancements in edge computing**: More powerful edge devices with lower latency and higher processing capabilities.
* **AI algorithm improvements**: The rise of new deep learning models, such as transformers for object detection, could improve accuracy and speed.
* **Communication protocols**: The rollout of **5G** and advancements in **IoT networks** would enable faster and more reliable data transmission, which could enhance real-time decision-making.

### **Personal Evaluation**

The Liverpool Smart Pedestrians Project demonstrates the feasibility and success of using advanced technology for urban planning in a rapidly growing city. The system provides a **cost-effective, scalable, and privacy-compliant** solution for traffic monitoring.

While the project is successful, there are areas for improvement. For instance, increasing the accuracy of the sensors could help address some of the challenges the system may face in the future. Expanding the range of data collected and providing more comprehensive insights could also benefit urban planners.

Overall, the project shows great potential, and with ongoing development, it could play a crucial role in shaping smart cities of the future.

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