**Main Goals of the Liverpool Smart Pedestrians Project:** The project aimed to monitor traffic flows (pedestrians, vehicles, bicycles) in urban areas using visual sensors. The data was collected and transmitted via LoRaWAN or Ethernet to aid in real-time traffic monitoring, supporting urban planners with informed decision-making while ensuring privacy by transmitting only meta-data.

**Urban Planning Challenges Addressed:**

* Traffic Flow Monitoring: Understanding movement patterns for better infrastructure planning.
* Circadian Rhythm of Activity: Capturing daily fluctuations in pedestrian and vehicle traffic.
* Privacy Concerns: Using meta-data to ensure privacy compliance.
* Connectivity Limitations: Enabling deployment in areas with limited or no internet access using LoRaWAN.

**Methodology Used in the Project:**

The project employed an edge-computing device for real-time traffic monitoring, designed around the NVIDIA Jetson TX2 platform. The sensor combined YOLO V3, a deep neural network for object detection, with the SORT tracking algorithm to monitor pedestrians, vehicles, and bicycles. Data was processed onboard and meta-data (such as counts and trajectories) was transmitted via Ethernet or LoRaWAN to an external platform, ensuring minimal bandwidth usage and privacy compliance. The device was deployed in both indoor and outdoor environments, including a city-wide deployment in Liverpool.

**Requirements and Constraints Considered:**

The sensor needed to function within the limits of the Jetson TX2’s processing power, with real-time detection and tracking. Optimization was necessary for low latency and energy efficiency, especially in remote areas with no internet access.

Connectivity: The use of LoRaWAN ensured deployment flexibility in areas with limited conventional internet infrastructure, while Ethernet was used where available.

Privacy: Only meta-data, not raw images, were transmitted to respect privacy regulations.

Accuracy and Performance: The project had to balance detection accuracy with processing speed (FPS), and improvements were sought to optimize detection algorithms and utilize GPU resources more effectively.

**Technology and Implementation**

Hardware and Software Components: The sensor uses the NVIDIA Jetson TX2 for local processing, leveraging its powerful GPU and CUDA cores for real-time object detection. The YOLO V3 algorithm detects objects, while SORT tracks them across frames. This setup allows the sensor to monitor traffic flow efficiently in real-time.

**Edge-Computing Paradigm:**

Edge-computing enables local data processing on the Jetson TX2, reducing latency, bandwidth use, and enhancing privacy by transmitting only meta-data. This approach aligns with edge-computing principles, improving efficiency and security in urban monitoring scenarios.

**Validation and Performance**

Validation Experiments: The sensor was validated in real-world environments, detecting 20,399 unique objects in a one-week outdoor deployment in Liverpool. It successfully tracked pedestrians, bicycles, and vehicles in various traffic conditions.

**Performance Insights:**

Accuracy: High detection accuracy for pedestrians and vehicles.

Speed: Real-time processing with YOLO V3 and SORT.

System Utilization: The Jetson TX2 efficiently managed real-time tracking with low power consumption and minimal resource strain.

**Real-World Applications**

Indoor Deployment: The sensor was deployed inside a building to monitor foot traffic during an emergency evacuation. It successfully tracked 631 individuals, revealing the building’s evacuation efficiency during a fire alarm. The sensor's ability to detect abnormal crowd movement provides valuable insights for improving emergency response strategies and planning.

Outdoor Deployment: In Liverpool, the sensor monitored pedestrian, bicycle, and vehicle traffic for a week. The collected data illustrated daily traffic patterns, which can help urban planners optimize traffic flow and manage public spaces. The sensor's ability to handle different traffic types in real-time, without compromising privacy, showcases its potential for smart city applications.  
  
In my opinion the Liverpool Smart Pedestrians project exemplifies the power of integrating edge computing with visual sensor technology for urban management. Its contributions to smart city initiatives, particularly in enhancing real-time monitoring and privacy-conscious data collection, are commendable. With some enhancements in detection accuracy, system scalability, and AI-driven predictions, this project has the potential to play a pivotal role in shaping the future of urban mobility and smart city infrastructure.