Demo: Real-time Camera Analytics for Enhancing Traffic Intersection Safety

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Abstract

Crowded metropolises present unique challenges to the potential deployment of autonomous vehicles. Safety of pedestrians cannot be compromised and personal privacy must be preserved. Smart city intersections will be at the core of Artificial Intelligence (AI)-powered citizen-friendly traffic management systems for such metropolises. Hence, the main objective of this work is to develop an experimentation framework for designing applications in support of secure and efficient traffic intersections in urban areas. We integrated a camera and a programmable edge computing node, deployed within the COSMOS testbed in New York City, with an Eclipse sensiNact data platform provided by Kentyou. We use this pipeline to collect and analyze video streams in real-time to support smart city applications. In this demo, we present a video analytics pipeline that analyzes the video stream from a COSMOS' street-level camera to extract traffic/crowd-related information and sends it to a dedicated dashboard for real-time visualization and further assessment. This is done without sending the raw video, in order to avoid violating pedestrians' privacy.

CCS Concepts

• **Computing methodologies** → **Object detection**; **Tracking**; **Activity recognition and understanding**; • **Networks** → **Cyber-physical networks**.

Keywords

Object detection, Camera networks, Smart intersection

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1 Introduction

This demo focuses on a first step toward using smart-cities infrastructure to build safe and efficient intersections while maintaining pedestrians' privacy.

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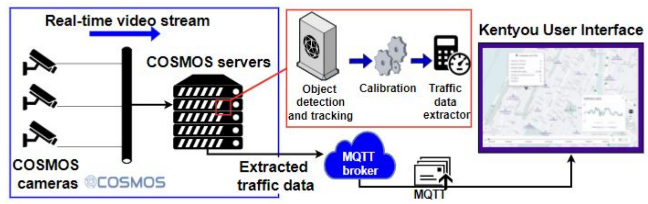

Figure 1: Video analytics and visualization pipeline: The video stream is analyzed in a server deployed at COSMOS testbed, then, the collected data is visualized in Kentyou UIs.

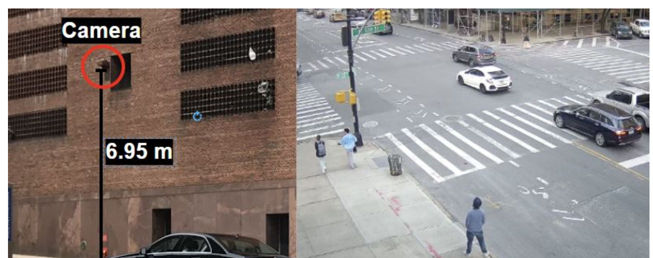

Figure 2: COSMOS camera deployed on the 2nd floor of Columbia's Mudd building and its view of the intersection.

We implemented a video analytics pipeline that processes the real-time video streams of traffic cameras, using AI algorithms, to identify and detect pedestrians/vehicles, the directions and speed of their movement, status of traffic lights, etc., in real-time. The pipeline (shown in Fig. 1) consists of sequential modules. The real-time stream from one of the NSF PAWR COSMOS testbed cameras [8–10], deployed at the 2^{nd} floor of Columbia's Mudd building (Fig. 2) looking at the intersection of 120^{th} street and Amsterdam Ave. in New York City, is transmitted to one of the COSMOS edge nodes for processing. There, traffic/crowd-related data of a batch of frames (e.g., 5 frames) is extracted. Then, an MQTT [6] message is created for each batch of frames. It includes the coordinates, IDs, speed, and direction of all detected pedestrians/vehicles, and the status of traffic lights. Only the MQTT message is sent to a central management platform, Eclipse sensiNact [5], developed by Kentyou, and therefore, privacy is preserved. The platform can use this data, along with other data sources (e.g., weather stations), for traffic anomaly detection, traffic-light cycles management, collision/accident detection, etc. It also visualizes the real-time traffic/crowd-related information using Kentyou User Interface (UI) (Fig. 3) and the historical information using Chronograf UI (Fig. 4).

There have been several efforts to use video analytics for traffic surveillance in dense urban areas, including automated detection of helmets on motorcyclists [1], detection of accidents/collisions in traffic videos [7], and alerts following anomalous traffic patterns [2]. A survey on visual traffic surveillance systems appears in [11]. In this demo, we go beyond the state-of-the-art and provide a more holistic view of the intersection by aggregating the traffic surveillance detection results, along with weather information and other analytics to better deal with safety concerns. Moreover, *it demonstrates the ability of the COSMOS platform to share real-time anonymized information with external systems and the ability of Kentyou's platform to interface with various external sensors.*

Below, we briefly describe the analytics component of the pipeline (Section 2.1), the communication between COSMOS and sensiNact (Section 2.2), the data visualization by Kentyou UI (Section 2.3), and the demonstration details (Section 3).

2 End-to-end Pipeline's Structure

2.1 Video Analytics Information Derivation

As illustrated in Fig. 1, the video analytics component of the pipeline, deployed in one of the COSMOS' nodes, includes multiple analytical modules:

- **Object detection and tracking:** detects and tracks pedestrians/vehicles and verifies the status of traffic lights. It uses YOLOv4 [3] object detector model and Nvidia DCF-based tracker.
- **Calibration**: uses multi-area calibration method [4] to convert on-image pixel coordinates to on-ground coordinates.
- **Traffic data extractor:** analyzes the output of the object detector and tracking module, and derives traffic/crowd-related information such as speed/direction.

The obtained information is sent to a central management platform (provided by Kentyou) for further statistical analysis and visualization. The data can then be used to detect traffic anomalies, improve roadway safety, manage traffic cycles, and find efficient routes.

2.2 SensiNact Integration with COSMOS

The sensiNact platform is an open-source framework hosted by Eclipse Foundation whose objective is to integrate and manage IoT devices, collect their data, and enable application development. To enable data collection from the COSMOS testbed, a sensiNact southbound connector was developed. This connector uses sensiNact's MQTT broker, which is a lightweight publish-subscribe protocol. Moreover, the Kentyou UI dashboard has been developed for visualizing the traffic/crowd-related information in real-time, receiving alerts, and providing recommendations based on the collected data. To support historical data storage, the generic InfluxDB storage mechanism, provided by sensiNact, is used.

2.3 Real-time Information Visualization

Kentyou UI provides information that can be useful for city agencies to better manage the city's intersections. Fig. 3 illustrates not only the real-time (e.g., number of vehicles and pedestrians) information but also some historical statistics (e.g., number of accidents in a month). A Chronograf dashboard is also available, providing traffic/crowd-related statistics from influxDB, as shown in Fig. 4.

3 Demonstration

In the demo, we present the design and the performance of the end-to-end pipeline, from data collection at the COSMOS testbed to visualization on Kentyou UIs.

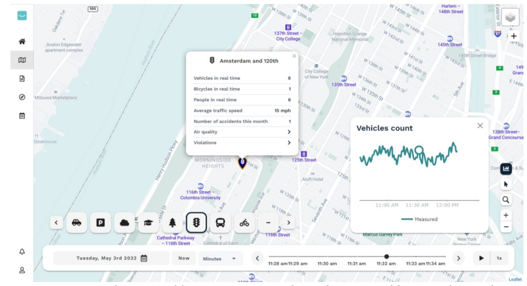

Figure 3: A sample UI illustrating the data collected and analyzed from the COSMOS testbed.

Figure 4: Dashboard providing the statistical information about the intersection.

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