Smart cities advantage

Nokia Scene Analytics - surveillance cameras as intelligent IoT sensors

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Introduction

In an effort to enhance public safety, traffic management, and crowd control, many cities have blanketed urban areas with video cameras. The trouble, though, is that video data centers are overloaded, transport networks are swamped, and privacy concerns have multiplied in step with camera deployment.

This application note focuses on the role that the Nokia Scene Analytics solution can play in helping cities overcome these challenges by using video cameras as Internet of Things (IoT) sensors. Our video analytics solution collects, filters, and combines all data types, and it understands and prioritizes the data in real time, in addition to providing scheduled reports. What’s more, the solution is massively scalable and secure — essential attributes for a video analytics solution that supports thousands of video feeds.

Figure 1. Video analysts currently face a deluge of video feeds.

Network and data center overload

Cities, such as London, have invested heavily in dedicated, purpose-built, coaxial cable transport networks. These networks transport video traffic to centrally located data centers continuously, daily. Despite efficiencies achieved by leveraging MPLS technologies, this type of high-volume video traffic storage and processing remains costly — even for well-funded surveillance programs. On top of that, the performance of video management systems, in general, has fallen well short of expectations.

Making matters more challenging, many cities lack sufficient resources. There aren’t enough people and the right software to fully analyze the flow of data and act on the findings. And scaling up with larger surveillance teams won’t necessarily solve this problem. That’s because traditional video recognition technology is ineffective under highly variable viewing conditions, particularly live city environments.

These conditions include changeable lighting, fast moving vehicles, and crowds of pedestrians navigating train stations, bus shelters, and airports.
Privacy concerns

Cities are also facing security-related pushback from residents. They worry about video cameras watching and recording their activities. Residents are also fearful that surveillance personnel will engage in voyeurism and that police departments might practice discrimination. Unsecured IP cameras are also vulnerable to online hackers who could access live feeds and stored footage.

All in all, what's needed is an intelligent and secure platform that proactively detects, selects, and tracks relevant video streams tied to prescribed surveillance tasks, even under highly variable conditions.

Figure 2. Centralized video processing is a large-scale and costly undertaking when thousands of cameras are networked.

Solution

Return on investment (ROI) of an IP camera network can only be realized when raw video is transformed into meaningful and actionable insights in real time. The Nokia Scene Analytics solution addresses high-volume network traffic, data center-related problems, as well as privacy concerns. To do this, the Nokia solution leverages supervised and unsupervised machine learning, pattern recognition, and behavioral knowledge. These capabilities anticipate what is situationally relevant based on prescribed surveillance tasks. For example, adaptive video anomaly detection can identify unexpected changes in video images, predict how subjects and situations evolve, and shift the camera's focus accordingly.

The Scene Analytics solution shines in real life situations, where crowds of people and/or poor lighting limits visibility and where traditional rules-based solutions are inadequate. Consider a car stalled at an intersection (see Figure 3). The video feed captures the scene. Some pixels in the video image “dwell” or stop moving while other pixels continue to move around the frame. This data establishes an anomaly compared to frames from an established norm. The Scene Analytics solution alerts the traffic surveillance officer so remediation steps can be taken immediately. Other examples include detecting the presence of a pedestrian, an accident, or a vehicle travelling in the wrong direction.
In addition to enhancing situational awareness, the solution prioritizes video streams according to relevance and alleviates the burden on humans to store and review every video feed.

The Scene Analytics solution overcomes the network and data center overload problems by turning IP cameras into IoT sensors. As a result, only a fraction of the massive set of video streams needs to be handled, transmitted, and stored. How does it do this? Abstract information vectors are derived from each video feed, including motion, direction, velocity, and density. Patented machine learning technology — developed by Nokia Bell Labs — analyzes these vectors in real time, establishes patterns, identifies anomalies, and generates alerts.

**Solution architecture**

Figure 4. Scene Analytics Solution Overview
Solution features

Scene Analytics uses a combination of Nokia-produced and open source computer vision and machine algorithms to turn cameras into smart IoT sensors. This fundamental capability provides the following applications:

Live video surveillance
Scene Analytics aims to reduce the amount of human review needed on real-time video streams. Various techniques are applied in-real time to do things like:

- Determine anomalous motion activity in a scene
- Filter motion within a subset of the scene
- Filter specific objects or activity detected in the scene (positively or negatively)
- Use external sensors (such as sound, badge reader, etc.) to trigger events.

The built-in video surveillance viewer or an external video management system (VMS) can be used to consume these alerts.

Forensic analysis
The events captured above are available for post-event review as well for a period of seven or more days. Users may apply forensic analysis to understand unusual activity that happened in the past for investigative or planning purposes.

Users can filter events by keyword or geo-spatially (on a map). Once the filter is applied, they can consume the alerts:

- Time-sliced by real-time, daily, weekly or monthly alerts
- Geo-spatially using the built-in map viewer
- By searching based on the metadata tags
- By using their own VMS; where Scene Analytics provides the event alert and metadata, but the VMS logic is used to review the footage.

Business intelligence
Scene Analytics has a built-in UI for person counting. Users may use this data to understand vehicle and people traffic flow to better plan their environment.

While vehicle and people counting are stock and included in the product, other objects counting are also available; exposed via Scene Analytics APIs, they allow for much rich customization of BI goals. Scene Analytics is now integrated with the Nokia SI Suite making it very easy to create custom business views based on the desired IoT application.
Multiple deployment models

Existing cameras in city networks feed video footage into a centralized video management system for archive and forensics; running in a data center, which aggregates the data. In contrast, the more flexible Nokia Scene Analytics solution supports multiple deployment models, including cloud, edge, and on-premises. It can also receive data using virtually any licensed and unlicensed wireless technology, including 3G, 4G/LTE, and Wi-Fi. This is advantageous for cities that want to establish a long-term relationship with a communications service provider (CSP) that needs to maintain a network using specific technologies.
 Typical city scenes: Examples

City surveillance and safety

Cities are installing more and more cameras around their cities but still struggle to understand what is happening around the city. Public safety staff monitor the city 24x7 and respond to events as they happen. IoT and video analytics are key real-time enablers.

Scene Analytics built-in anomaly detection algorithm is most useful when it is able to detect anomalies contrary to the motion norm. Some real-life examples:

• Panic scene: People are walking up and down a sidewalk and now there is suddenly an unsafe event so the crowd runs in multiple directions. That would likely trigger a direction anomaly.

• Crate left in middle of the aisle: A retail or industrial scenario where people are normally moving suddenly has a large object in the scene. This would likely trigger a dwell anomaly.

• A sudden explosion, thick smoke: The ML algorithm should learn that if a dense dark fog/cloud is in the scene then it should trigger a density anomaly.

• Fast driver: The ML algorithm should learn the normal speed of traffic (that is, the velocity of pixel norm). If suddenly a fast driver moves through the road, the ML algorithm should see this unusual sudden motion and trigger a velocity anomaly. Note that velocity anomalies are never triggered in isolation, they are typically accompanied by dwell or density anomalies.
Below are some other useful cases for anomaly detection:

**Figure 7. When and where is automatic anomaly detection needed – Use cases**

### Venues
- Parks
- Stadiums
- Concert halls
- Airports
- Train stations
- Substations
- Busy city streets
- Highways
- Parking lots
- Amusement parks
- Construction sites

### Surveillance/safety
- Forbidden walk path (e.g., airport exit path)
- Someone running through the baggage area in an airport
- People jumping over or going under a turnstile
- After hour activity near or in a large venue (park, concert hall, stadium)
- Abandoned object on a street or placed near crowds for an event
- Perimeter surveillance such as border control

### Urban planning
- Measure popular storefronts and billboards in shopping mall for planning purposes
- Observe people and car traffic to make cities more walkable and liveable

### Traffic engineering and safety
- Detect car taking wrong turn or wrong way
- Detect oversized vehicles
- Stalled car
- Debris or animal in the roadway
- Measure traffic densities for various uses such as helping with traffic signal phasing

### Roadway planning, surveillance and safety
Roadway authorities are increasingly being responsible for reducing road fatalities, keeping traffic on time and citizens informed. They desire to improve response time to life-threatening vehicle accidents leveraging existing video surveillance and other IoT data.

Scene Analytics provides:
- Monitoring of roadways with unusual activity and analytics provided by computer vision
- Integration of roadway sensors to trigger alerts
- Detection of car taking wrong turn or wrong way
- Detection of stalled car, debris or animal in the roadway
- The ability to measure traffic densities for various uses such as helping with traffic signal phasing.

### Summary
Widespread video surveillance using IP cameras is becoming a hallmark of smart cities. Getting the underlying analytics framework right is critical to assure proactive response and a healthy ROI. By deploying the Nokia Scene Analytics solution, cities can improve security and quality of life for residents, achieve significant bandwidth savings, remedy data center overload, and reduce overall video surveillance costs.
About Nokia IoT solutions

Nokia brings the Internet of Things (IoT) to life for smart cities, creating the seamless fabric that stimulates economic growth and enables a more livable and better-connected society.

Nokia is uniquely positioned to help large enterprises, governments, and communications service providers (CSPs) deliver on the promise of smart cities. Our solutions are designed to provide a shared, secure and scalable platform that ensures the best use of urban resources and data to enable the human possibilities of smart, safe and sustainable cities.

Nokia is a leading IP networking, ultra-broadband access, and cloud specialist. We have the right assets to partner with M2M service providers, enterprises, utility providers, and public administrations to build the infrastructure for the Internet of Things.

Visit our web page on the nokia.ly/IoTapplications to learn more about our IoT solutions.