Information-Driven Video Communication for Public Safety Networks

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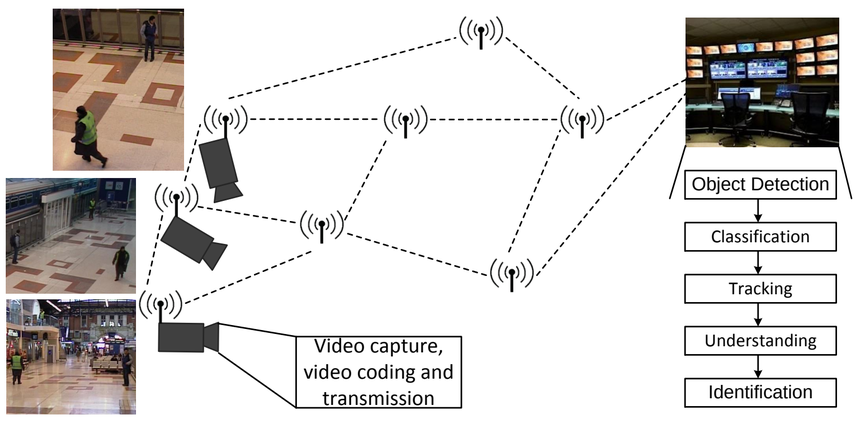
(Participants include law enforcement officers and parking services employees)

Background

- **Networked video surveillance systems** have been used heavily in today's public safety infrastructure.
- More and more **wireless cameras** are deployed, and there is an increasing demand of **bandwidth** for delivering surveillance videos.
- Automatic video analysis tools, which attempt to detect, recognize, track objects, and understand their behaviors, have been applied in surveillance systems to provide real-time analysis results.



- Applying **automatic video analysis at network edges** in a distributed manner can potentially
  - alleviate the bandwidth pressure;
  - enable better real-time response to users.

Objective

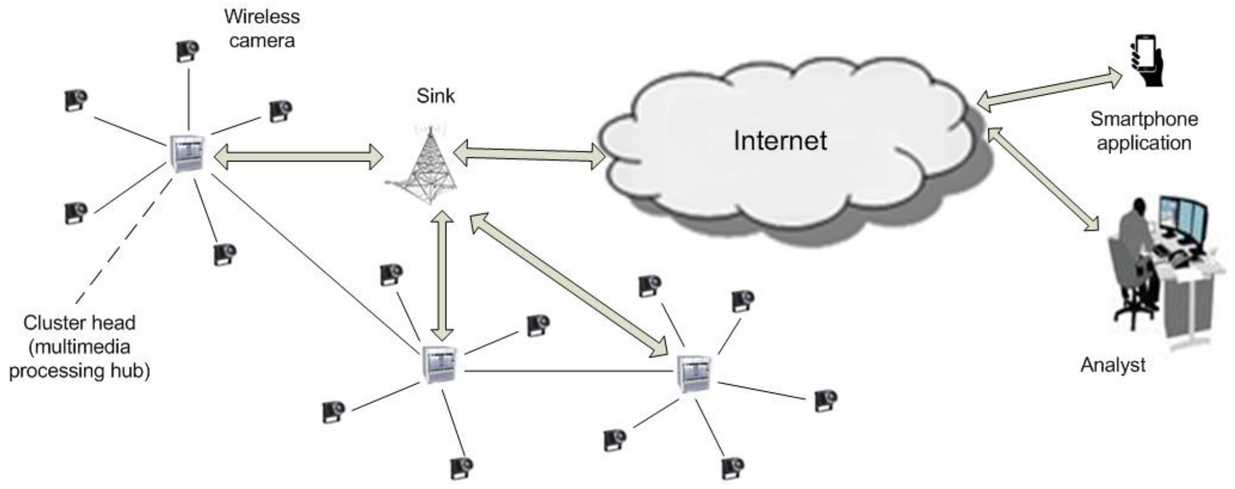
- Design an information-driven video communication framework for wireless surveillance systems with the objective to **maximize the information that human operators could gain with the help of automatic video analysis.**

Methodology

- Existing work
  - Traditional communication protocols aim to satisfy QoS (quality of service) or QoE (quality of experience) requirements. However, QoS and QoE do not directly reflect the amount of information that could be gained from a wireless surveillance system.
- Proposed work
  - Bridge the gap between the quality requirements from public safety video users and the research in wireless networking and distributed in-network data analysis.
  - Quantify the quality of information for wireless surveillance applications and design networking solutions to maximize the information gain.

Research Plan

- **Task 1: Building analytical quality of information (QoI) models for the visual information obtained from distributed automatic video analysis.**
  - Statistical analysis on a large amount of video traces which align with common use cases of surveillance video analytics.
  - Explore features related to several sources of information loss, including lossy video compression, packet losses and delays, and the computational limitations of local data processing.
  - Establish relationships between QoI and the features.



- **Task 2: Designing communication protocols to support efficient and real-time distributed in-network video analysis.**
  - In a hierarchical clustered network, use intra-cluster and inter-cluster communication to enable the collaboration of cameras.
  - Design channel access, scheduling, and routing protocols for multiple cameras to extract the maximum amount of information through in-network processing.
- **Task 3: Designing an information-driven video streaming application to effectively disseminate visual information from surveillance cameras to human operators.**
  - Deliver bandwidth-consuming visual information, including raw video and analysis results, to first responders in real-time.
  - Design and develop a scalable video streaming application to adjust to the available bandwidth for human operators connected to the surveillance network.
  - Perform QoI-aware rate control to maximize the quality of information delivered to human operators.

Major Milestones

- Task 1: Year 1 months 1-12 and Year 2 months 1-6.
  - Month 3 of Year 1: Finish collecting raw video data and gathering sample use cases from our partner.
  - Month 3 of Year 2: Finish gathering QoI evaluation results on our test datasets from our partner.
  - Month 6 of Year 2: Complete the QoI models.
- Task 2: Year 2 months 1-12.
  - Month 12 of Year 2: Complete the design and evaluation of the proposed intra- and inter- cluster communication protocols.
- Task 3: Year 3 months 1-12.
  - Month 6 of Year 3: Finish the design and evaluation of the proposed video streaming application.
  - Month 12 of Year 3: Complete the joint evaluation of the research components in Tasks 1-3.

Expected Impact

- Enable efficient and real-time distributed in-network video analysis under bandwidth limitations for surveillance systems.
- Enhance the situational awareness of first responders.
- Increase the speed and precision of decision making for various incidents in public safety.
- The software and evaluation platforms resulted from this project will be made available for the research community for further studies on video surveillance systems.