Université Constantine 2
جامعة قسنطينة 2

Artificial Vision

Course 5

Chapter 5 : Video Surveillance of Human Activity

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Chapter 5 : Video Surveillance of Human Activity

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Etudiants concernés

Faculté/Institut	Département	Niveau	Spécialité
Nouvelles technologies	/	Master 2	Sciences de Données et Intelligence Artificielle (SDIA)

Summary

Prerequisites

- Mathematical Notions
- Algorithmic Notions

Course Objective

- A look into video surveillance process and activities

OUTLINE

- ✔ Definition of video surveillance
- ✔ **Historical Overview**
- ✔ **Core Concepts in Video Surveillance**
  - ✔ Components of video surveillance systems
    - Cameras and sensors
    - Storage and processing units
  - ✔ Types of video surveillance
    - Real-time vs. recorded
    - Passive vs. active monitoring
- ✔ **Human Activity Recognition (HAR)**
- ✔ **Challenges in Human Activity Surveillance**
- ✔ **Case Studies and Examples**
- ✔ **Conclusion**

DEFINITION

Video surveillance involves the use of video cameras to observe, monitor, and record activities within a specific area to enhance security, gather information, or monitor behaviors.

Key Aspects:

- Monitoring activities to detect unusual or suspicious behavior.
- Enhancing security by deterring criminal actions and providing evidence for investigations.

Benefits:

- Real-time monitoring and instant alerts for potential threats.
- Cost-effective compared to human surveillance.

Example Applications:

- **Public Safety:** Monitoring public spaces like parks, malls, and streets to prevent crime.
- **Healthcare:** Observing patients and ensuring safety in hospitals and elder care facilities.
- **Smart Homes:** Detecting intrusions, managing deliveries, and ensuring household safety.

Video surveillance applications

Historical overview

✔ Historical Overview

- **Analog Era:**
  - Basic analog cameras used for video monitoring without automation.
- **History of Analog Cameras:**
  - 1942: Siemens introduced the first closed-circuit television (CCTV) system, "Vericon," in Germany.
  - 1960s: Analog CCTV systems became commercially available for use in banks and stores.
  - 1970s: Cameras were employed for urban security, such as monitoring public spaces in New York.
  - 1980s: VCR technology enabled video footage storage, boosting surveillance capabilities.
  - 1990s: Analog cameras improved in image quality and affordability, dominating the market before digital technology emerged.

✔ Historical Overview

- **Digital Era:**
- 1990s: Introduction of digital surveillance systems with features like higher resolution and better storage capabilities.
- 2000s: Emergence of IP (Internet Protocol) cameras, enabling remote monitoring via the internet.
- 2010s: Integration of cloud storage, enhancing accessibility and scalability of surveillance systems.
- Late 2010s: Adoption of AI-powered analytics for automated threat detection and activity recognition.
- 2020s: Increased use of edge computing and IoT for real-time, decentralized processing in surveillance systems.

Historical overview

Key concept

✔**Core Concepts in Video Surveillance**

✔Components of video surveillance systems

- **Cameras and Sensors:**
  - Types of cameras (fixed, PTZ, thermal,,etc).
  - Additional sensors (motion detectors, infrared).
- **Data Storage Solutions:**
  - Cloud storage for scalability.
  - Edge storage for real-time processing.
- **Processing Units:**
  - Use of Graphics Processing Units (GPUs) and Tensor Processing Units (TPUs) for high-performance analytics

Key concept

- **Types of Cameras:**
- **Analog Cameras:** Cost-effective with basic recording capabilities, reliant on coaxial cables and VCRs (Video Casset Recorder) for storage.

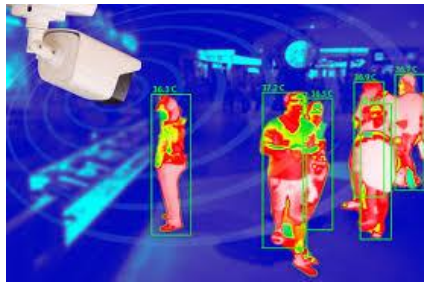
- **Digital Cameras:** Offer higher resolution, better storage, and integration with modern technologies like cloud systems.

- **IP Cameras:** Enable remote access and real-time monitoring over the internet.

- **PTZ Cameras (Pan-Tilt-Zoom):** Allow dynamic control for covering wide areas and zooming in on specific details.

Key concept

- **Types of Cameras:**
- **Thermal Cameras:** Detect heat signatures, useful in low-light or no-light conditions for security and search applications.



- **Dome Cameras:** Compact and vandal-resistant, ideal for discreet indoor or outdoor surveillance.

- **Bullet Cameras:** Cylindrical and highly visible, suitable for long-range outdoor monitoring.

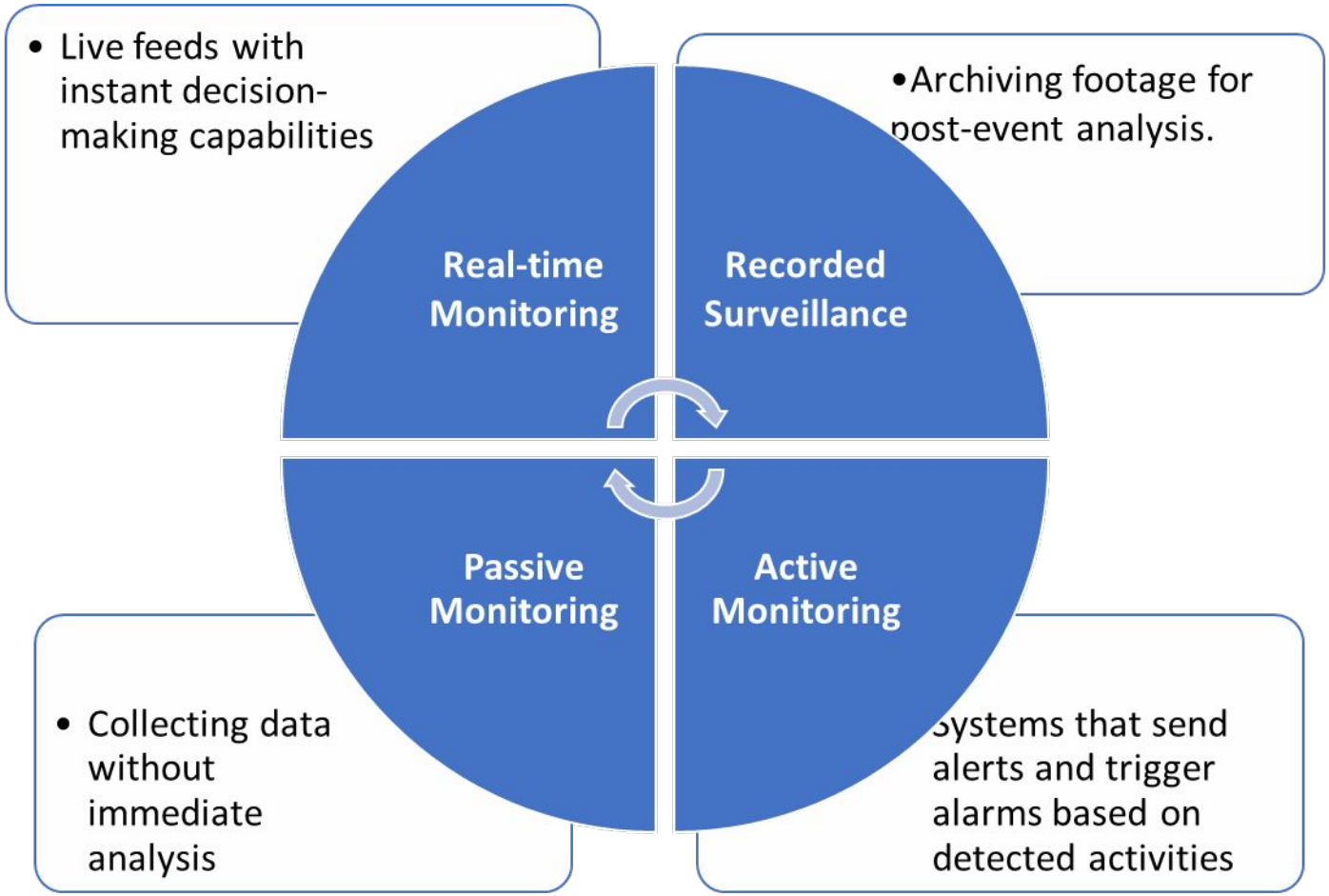
- **360-Degree Cameras:** Provide comprehensive views of an area with minimal blind spots.

differences between analog and digital cameras

Aspect	Analog Camera	Digital Camera
Transmission	Transmits analog signals over coaxial cables to a DVR(Digital Video Recorder)	Transmits digital signals over IP networks to an NVR (Network Video Recorder) or cloud.
Image Quality	Lower resolution, limited by signal and hardware.	High-definition (HD) and ultra-HD quality with better clarity.
Scalability	Limited scalability; adding cameras requires additional infrastructure.	Easily scalable through network integration.
Features	Basic functionality; limited analytics capabilities.	Advanced features like motion detection and facial recognition.
Cost	Lower upfront costs; affordable maintenance.	Higher upfront costs but more feature-rich.
Cybersecurity	Not networked, less susceptible to hacking.	Requires network security measures; can be hacked if not secured.

Key concept

Types of Video Surveillance



Human Activity Recognition

Human Activity Recognition (HAR)

Overview of HAR

- **Definition and Significance:**
  - Recognizing and interpreting human behaviors in video footage.
- **Examples of Recognized Activities:**
  - Daily activities: walking, running, sitting, and falling.
  - Complex actions: group gatherings, hand gestures.

Human Activity Recognition

Techniques for HAR

- **Rule-based Systems:**
  - Predefined thresholds and heuristics.
- **Machine Learning Algorithms:**
  - Supervised and unsupervised learning approaches.
- **Deep Learning:**
  - CNNs for spatial recognition.
  - RNNs for sequential patterns.

Challenges in Human Activity Surveillance

1 Environmental Challenges

- **Lighting Conditions**

  Example: Surveillance in poorly lit areas like parking lots or nighttime streets often fails to detect activities accurately.

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- **Weather Conditions**

  Example: Dense fog can blur video feeds, as shown in highway traffic monitoring systems.

- **Occlusion**

  Example: In crowded urban areas, people often occlude each other, complicating tracking.

Challenges in Human Activity Surveillance

2. Complexity of Human Behavior

- **Variability in Activities**

  Example: A single person might switch between walking, running, or pausing, which adds complexity to recognition models.

- **Interpersonal Interactions**

  Example: Detecting a fight in a crowded stadium requires distinguishing aggressive interactions from benign gestures.

- **Subtle Activities**

  Example: Detecting pickpocketing in a marketplace requires attention to small hand movements.

Challenges in Human Activity Surveillance

3. Data Challenges

- **High Dimensionality**

  Example: Surveillance in a smart city generates terabytes of video data daily, overwhelming traditional systems.

- **Annotation**

  Example: Creating a labeled dataset for elder fall detection in homes involves extensive manual labor.

- **Imbalanced Datasets**

  Example: Violent activities make up less than 1% of footage but are crucial to detect.

Challenges in Human Activity Surveillance

4. Technical Challenges

- **Real-time Processing**
  Example: Real-time traffic monitoring on highways necessitates low-latency systems.

- **Multi-camera Coordination**
  Example: Coordinating cameras in a shopping mall to track a suspect across multiple floors.

- **Privacy Preservation**
  Example: Using anonymization techniques to blur faces in retail surveillance.
  Reference: Sun et al. (2022) propose privacy-preserving methods for public area surveillance.

Challenges in Human Activity Surveillance

5. Robustness of Algorithms

- **Adversarial Scenarios**
  Example: Suspects use masks or props to deceive facial recognition systems.

- **Adaptability**
  Example: Updating models for new activities like e-scooter usage in urban surveillance.

- **False Positives/Negatives**
  Example: Mistaking a handshake for a fight in event monitoring.

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Challenges in Human Activity Surveillance

6. Ethical and Legal Concerns

- **Bias in AI Models**
  Example: Systems performing worse on non-Western demographic groups.

- **Surveillance Misuse**
  Example: Using surveillance for political targeting.

- **Regulatory Compliance**
  Example: GDPR regulations require anonymizing personal data in European surveillance systems.

Challenges in Human Activity Surveillance

7. Integration with Other Technologies

- **IoT Devices**
  Example: Using IoT sensors for movement detection enhances video surveillance accuracy.
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- **Edge Computing**
  Example: Processing on edge devices reduces latency in stadium surveillance.
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- **Security**
  Example: Cyberattacks targeting surveillance feeds to delete evidence.

Challenges in Human Activity Surveillance

8. Scalability

- **Large-scale Deployment**
  Example: Monitoring public transportation hubs requires scalability.

- **Resource Allocation**
  Example: Allocating bandwidth for high-priority areas like banks or government buildings.

Case study

Here are notable case studies and examples of video surveillance in human activity monitoring across various sectors:

1. Public Safety and Crime Prevention
Case: London's CCTV Network (UK)

- **Context**: London has one of the world's most extensive CCTV networks, covering streets, subways, and public spaces.
- **Purpose**: Monitor crowd activities, prevent crimes, and support law enforcement.
- **Outcome**: CCTV footage has been instrumental in solving cases like the 2005 London bombings. Challenges included privacy concerns and system scalability.

Case study

2. Smart Cities
Case: Singapore's Smart Nation Initiative

- **Context**: Singapore integrates video surveillance with IoT sensors in public spaces.
- **Purpose**: Monitor traffic, detect unusual activities, and manage public safety.
- **Outcome**: Enhanced response times to emergencies and improved urban planning. Challenges involve data management and maintaining citizen trust.

Case study

3. Traffic Monitoring

Case: Dubai's Smart Traffic Management System

- **Context**: The city integrates surveillance cameras with AI for real-time traffic monitoring.
- **Purpose**: Detect traffic violations, manage congestion, and monitor pedestrian safety.
- **Outcome**: Improved traffic flow and reduced accident rates.

Case study

4. Military and Border Surveillance

Case: US-Mexico Border Surveillance

- **Context**: Surveillance systems are deployed to monitor human activities along the border.
- **Purpose**: Detect illegal crossings and ensure border security.
- **Outcome**: Enhanced detection capabilities but faced criticism for ethical concerns and high costs.

The U.S.-Mexico border surveillance employs cameras, sensors, drones, radar, smart fences, biometric systems, mobile units, and AI analytics to monitor and secure the border effectively.

Conclusion

With continuous advancements in AI and integration with **IoT**, video surveillance has the potential to become more accurate, scalable, and ethically responsible, paving the way for safer and smarter environments.

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