Automatic Detection of Abnormal Events in Surveillance Videos for Online Processing and Low-cost Devices

Victor Sanchez, PhD

Abstract: Several methods to detect abnormal events in video data have been recently proposed. Unfortunately, there is a lack of methods capable of detecting these events as frames are acquired, also known as online processing. Moreover, the computational complexity of many of these methods makes it very challenging to implement them in low-cost devices with low computational capabilities, such as mobile devices and those used in embedded applications. In this tutorial, we will review and explain the two main approaches used to design automatic video anomaly detection methods: traditional machine learning and deep learning. For each approach, we will explain and discuss their advantages and disadvantages for low-cost devices and online processing. This tutorial will provide a solid technical background on the design of automatic video anomaly detection when complexity and training and processing times are important concerns.

Format of the tutorial: half-day.

Motivation and Focus

Big data continues to grow exponentially and surveillance video has become one of the largest sources. This is evident by the increasing number of surveillance cameras throughout our surroundings, e.g., in elevators, ATMs, and other public places. To fully exploit the data acquired by these cameras, it is important to develop automatic video surveillance methods capable of intelligently analyzing and understanding the visual information. At the core of automatic video surveillance are anomaly detection methods, which have been shown to be highly effective to detect unusual events without *a priori* knowledge about these events. Examples of abnormal events within the context of video surveillance are robberies, street fights, acts of vandalism, breaks-in, and unusual crowd movements. Despite important advances in video anomaly detection over the past decade, there is a lack of methods specifically designed for online processing and for mobile and low-cost devices, which deters its applicability especially in embedded applications. Moreover, research on realistic surveillance videos is still limited. State-of-the-art methods have been mainly designed and tested using datasets that poorly represent realistic abnormal events. These datasets usually contain simulated scenes with actors behaving abnormally, or more realistic scenes but with a very limited number of abnormal events.

In this tutorial, we will first explain the challenges behind video anomaly detection, showing examples of abnormal events as captured by surveillance cameras. We will then introduce and explain the two main approaches commonly used to design video anomaly detection methods: traditional machine learning approaches and deep learning approaches. For each type of approach, we will first review and explain the technical components required to extract features in time and space useful to distinguish normal events from abnormal ones. We will then explain and discuss their advantages and disadvantages from the point of view of online processing and suitability for embedded applications and mobile devices. These explanations will focus on:

1. Training and processing times.
2. Computational complexity.
3. Memory requirements.
4. Detection accuracy as characterised by the Receiver Operating Characteristics (ROC) curve, the Equal Error Rate (EER), and over the Area Under the Curve (AUC)).
5. Energy requirements of their hardware implementations.

The final part of this tutorial will focus on a review of the existing datasets commonly used to train and test video anomaly detection methods.

Syllabus

At the end of this tutorial, the attendees are expected to learn the main technical concepts needed to design automatic video anomaly detection methods using traditional machine learning approaches and deep learning approaches. The attendees will also learn the advantages and disadvantages of each type of approach for online processing and low-cost devices. The three specific topics to be covered are:

I. Introduction to abnormal event detection in surveillance videos
    a. Challenges in defining abnormal events to be detected *a priori*
    b. Examples abnormal events in surveillance video

II. Automatic abnormal event detection
    a. Machine learning approaches
        i. Feature extraction in time and space
            1. Optical flow features
            2. Foreground occupancy feature
            3. Histogram of Optical Flow (HOF) feature
        ii. Inference model
        iii. Training and testing
            1. Detection accuracy
            2. Training and processing times
            3. Computational complexity
            4. Memory requirements
            5. Energy requirements
    b. Deep learning approaches
        i. Feature extraction in time and space
            1. Convolutional Neural Networks
            2. Recurrent Neural Networks
            3. Autoencoders
        ii. Inference model
        iii. Training and testing
            1. Detection accuracy
            2. Training and processing times
            3. Computational complexity
            4. Memory requirements
            5. Energy requirements

III. Datasets for training and evaluation
   a. UCSD Dataset
   b. Subway Dataset
   c. CUHK Avenue Dataset
   d. ShanghaiTech Campus Dataset
   e. LV Dataset
   f. UMN dataset

Speaker

Dr. Victor Sanchez is an Associate Professor of Computer Science at University of Warwick, Uk. He leads the Signal and Information processing (SIP) Lab, which is part of the umbrella Artificial Intelligence (AI) Group, which has a well-established reputation for the quality of its research in signal processing, computer vision and machine learning. Dr Sanchez has published over 100 research papers in signal processing and machine learning. His research has been supported by major funding agencies in North America, Europe, and the UK. He has led projects on image and video processing supported by the EU FP7 Program, and the Engineering and Physical Sciences Research Council (EPSRC) of the UK. These projects included *MIUSS: Machine Intelligent in Urban Security Systems*, funded by the EPSRC, and *I-SeC: Intelligent and Secure Cities*, funded by the Newton Fund International Collaboration Programme and the Mexican Academy of Sciences.