Chapter 6
Object-Oriented Logic Programming of Intelligent Visual Surveillance for Human Anomalous Behavior Detection

Alexei Alexandrovich Morozov
Kotel’nikov Institute of Radio Engineering and Electronics of RAS, Russia

Olga Sergeevna Sushkova
Kotel’nikov Institute of Radio Engineering and Electronics of RAS, Russia

Alexander Fedorovich Polupanov
Kotel’nikov Institute of Radio Engineering and Electronics of RAS, Russia

ABSTRACT

The idea of the logic programming-based approach to the intelligent visual surveillance is in usage of logical rules for description and analysis of people behavior. New prospects in logic programming of the intelligent visual surveillance are connected with the usage of 3D machine vision methods and adaptation of the multi-agent approach to the intelligent visual surveillance. The main advantage of usage of 3D vision instead of the conventional 2D vision is that the first one can provide essentially more complete information about the video scene. The availability of exact information about the coordinates of the parts of the body and scene geometry provided by means of 3D vision is a key to the automation of behavior analysis, recognition, and understanding. This chapter supplies the first systematic and complete description of the method of object-oriented logic programming of the intelligent visual surveillance, special software implementing this method, and new trends in the research area linked with the usage of novel 3D data acquisition equipment.

INTRODUCTION

A research area of rapidly growing is the human behavior recognition on the base of the intelligent visual surveillance. This research area is very important for applications such as security and anti-terrorism issues. A promising approach for dynamic visual scenes analysis is the logic programming. The idea of
the logic programming approach to the intelligent visual surveillance is in the usage of logical rules to formulate the description of context information and the analysis of people behavior. The behavior and activity notions differ in that the behavior of an object is the activity of the object related to the context information about the place, time, object attributes, etc. The information about the context allows deciding, for instance, whether the behavior of the object is abnormal or dangerous. Thus, the analysis of the behavior is a more complicated problem than the analysis of the activity. It is necessary to describe and analyze the information about the context of the activity and the mathematical logic is perhaps the best instrument that can be used for this purpose. The logic-based approach to the people behavior analysis and the intelligent visual surveillance has the following advantages:

1. One can easily incorporate domain knowledge into the recognition process in the form of logical formulae.
2. Reasoning about the behavior of people can be very difficult, but for the developer of the system of the intelligent visual surveillance, it always remains fundamentally understandable.
3. One can easily define a complex activity in terms of simpler activities.

In this chapter, research software for logic programming of the intelligent visual surveillance systems is discussed and examples of logic programs for video analysis are represented. The software is based on the Actor Prolog concurrent object-oriented logic language and a state-of-the-art Prolog-to-Java translator. Built-in classes of the Actor Prolog logic programming system are implemented in Java. The low-level stage of the video processing is implemented in special built-in classes of Actor Prolog. The purpose of the software developed is to facilitate research in the area of intelligent video monitoring especially for the evaluation of anomalous people activity and the study of logical description and analysis of people behavior. The open source library of the built-in classes is published in GitHub (Morozov, 2018).

A promising approach to implement the logic programming in the video analysis is the translation from the concurrent object-oriented logic language to Java. The means of the object-oriented logic programming enable fast and effective processing big arrays of video data because the arrays of data can be encapsulated in the instances of specialized built-in classes in the object-oriented logic language. The Actor Prolog logic programming system is suitable for this purpose since it is fast enough for the real-time video processing and ensures essential separation of the recognition process into concurrent sub-processes implementing different stages of the high-level video analysis. Generation of Java intermediate code ensures platform independence of the application software and guarantees absence of errors, such as the difficult-to-locate bugs (for instance, caused by memory leaks) and the out-of-range array operations.

The use of an industrial Java virtual machine for the logic programming system enhances its flexibility and simplifies adaptation to new operating systems and processor architectures. New prospects in the logic programming of the intelligent visual surveillance are connected with the usage of 3D machine vision methods and adaptation of the multi-agent approach to the intelligent visual surveillance. The usage of 3D data acquisition equipment like time-of-flight (ToF) cameras, structured light sensors, stereo cameras, laser scanners (LiDARs), and Flash Ladars open new prospects in the area of the intelligent visual surveillance. 3D data make possible to solve complicated problems of computer vision caused by the presence of shadows, variations in illumination, viewpoint changes, cluttered background, and occlusions; however, there is no universal 3D data acquisition equipment for solving all computer vision problems. The main advantage of 3D vision is in that it can supply essentially more complete informa-