Electronic Observation and Computer Monitoring of Human Behavior in Public Space

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Introduction

Security is value, which become more and more desirable while we must note dramatically increasing quantity and weight of numerous dangers related to particular persons, to different populations and to almost everybody and everywhere. Therefore we can observe up-to-date fast and massive increase of social requisition in the area of protection against terroristic attacks and hapless random events. Even fanatic privacy defenders, who in the past often protested against surveillance, now must take into account scale of threats which is generated by actual political and social tensions, and must agree for inconsiderable limitations of privacy (in public space) when it is connected with huge increase of public security. Therefore now the question is not whether oversee of human behavior in public space – but how to do it?

Surveillance video has become one of the most important means for criminal investigation in recent years. In this particular application, investigators often needs to detect and track a specific suspect in a large-scale spatial region covered by multiple non-overlapping cameras. In this paper only part of this problem will be presented and discussed. We try show, how use computers and artificial intelligence methods for effective monitoring of human behavior in public space. Automatic (computer based) methods of such monitoring is necessary, because devices used for electronic observation of the people in public space (different types of analog and digital cameras) become cheaper and cheaper. Moreover installation and handling of these cameras become easier and easier. It can be performed literally by everybody, even by persons without any technical knowledge. Therefore number of observation cameras localized in public space dramatically increase, when problem, how to use such huge amount of visual information, remains open and difficult. Comprehensive discussion of different methods used for solving such problems using advances computer vision technologies – will be presented during this keynote lecture. In this abstract we take into account only some example solutions and give references.

Presented paper is based on results three year research in SIMPOZ project (grant over 2 million PLN given by Polish Ministry of Science and Higher Education Nr. 28/R/t00/2010/12) where team of over twenty scientist working under management exercised by author of this article developed system for intelligent monitoring and surveillance of space and objects special importance [6]. The name SIPMPOZ is abbreviation Polish couple of word describing desired properties od formed system (SIPMPOZ = System Inteligentnego Monitoringu Przestrzeni i Obiektów szczególnego Znaczenia = System for Intelligent Monitoring of Space and Objects of Special Imprtance). The most important goal of considered system was related to electronic observation and computer monitoring of human behavior in public space – and this part of our research as well.

System for electronic observation and computer monitoring of human behavior in public space consist of several components (see Fig. 1):

- image acquisition subsystem collecting signals from many cameras, producing at the output huge amount of data in form of image sequences;
- control center with professional security guards;
- image processing subsystem (noise filtering, shadows suppressing, background elimination etc.);
- image analysis (persons localization);
- people motions tracking;
- people behavior interpretation.

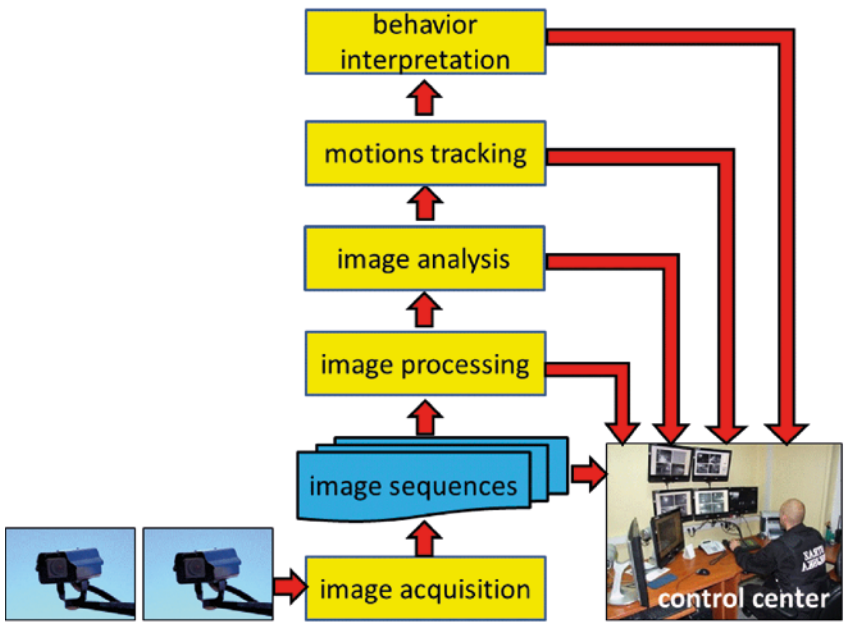

Fig. 1. General structure of considered system

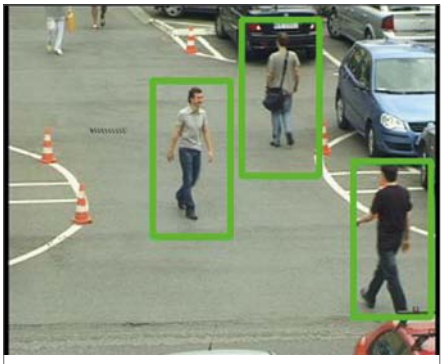

Fig. 2. Localization of persons on the image – well working in easy case [6]

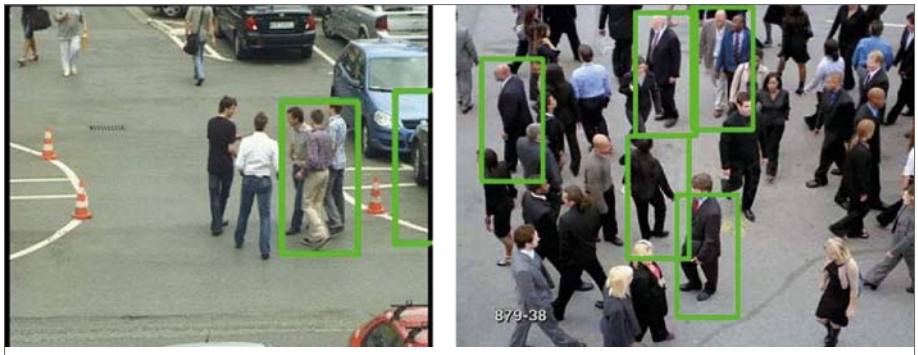

Fig. 3. Wrong person localization in more complicated situations [6]

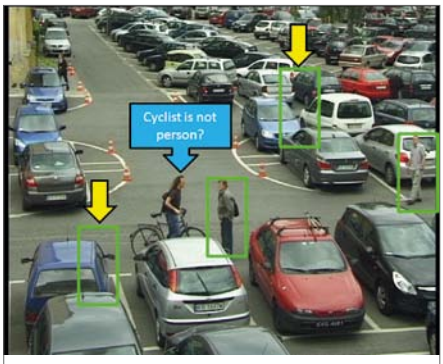

Fig. 4. False recognition of persons on the image (pointed). Cyclist is not a person? [6]

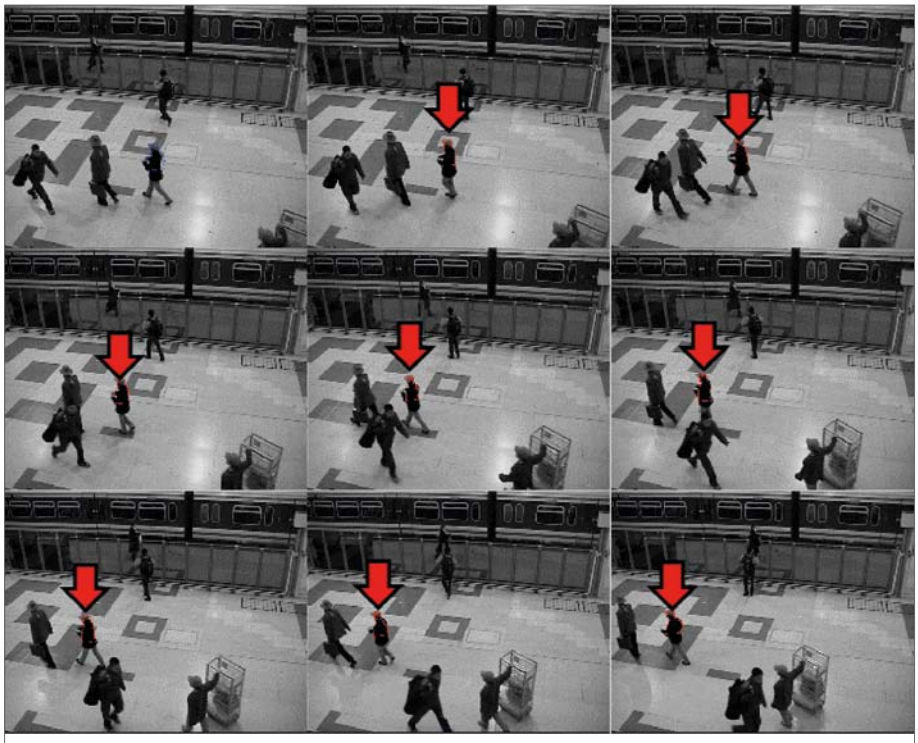

Fig. 5. Determining for the consecutive images tracked person locations and its changes we can establish trajectory of the person movement [6]

Image processing and analysis subsystems

Noise filtering problem is typical computer vision task and methods used for this purpose in computer monitoring of human behavior are typical ones, similar to methods used in numerous other applications. Therefore this part of the system is out of the discussion in this paper [6].

Most important part of image analysis subsystem for computer monitoring of human behavior is persons localization algorithm. This task is relatively easy if number of visible persons is not very big and background not include forms, which in automatic human recognition module can be identified as persons. Moreover persons should be not very close one to other. On figure 2 is shown such easy case and perfect persons localizations (green rectangles) can be observed.

When number of persons increase and distances between persons narrowing – automatic person localization methods can be confused and not work properly (Fig. 3).

On figure 3 many persons are omitted (not localized properly), but much worse situation is presented on figure 4, where some configurations of different elements of the scene are identified as persons.

The best solution for considered problem is algorithm DTDPM (Discriminatively Trained Deformable Part Models) described in [3].

Tracking of people motions

After persons detection and localization very important part of computer system for monitoring of human behavior in public space is people motions tracking module. The principle is easy: Motion tracking can be accomplished by identifying the same person in several successive images, forming temporal sequence (video record). Determining for the consecutive images tracked person locations and its changes we can establish trajectory of the person movement (Fig. 5).

It is so easy only in very simple cases. In fact sometimes using this method we cannot track individual trajectory of particular person, because continuous monitoring of one person on sequential images can sometimes be erroneous. On Fig. 6 we can observe situation, when tracking

was confused during close passing of two persons. Therefore tracking the movement of observed persons must be supplemented by checking whether we constantly have to deal with the same person. This can be achieved, inter alia [1], on the basis of the observed person clothes color histograms.

Sometimes instead of tracking full person silhouette better is make tracking of selected characteristic and easy for identification points on the image. Couple of trajectories of such points can be used instead of trajectory of whole person with similar results (Fig. 7).

Using described method we can observe every particular person and keep his (or her) identification even during long walk (Fig. 8).

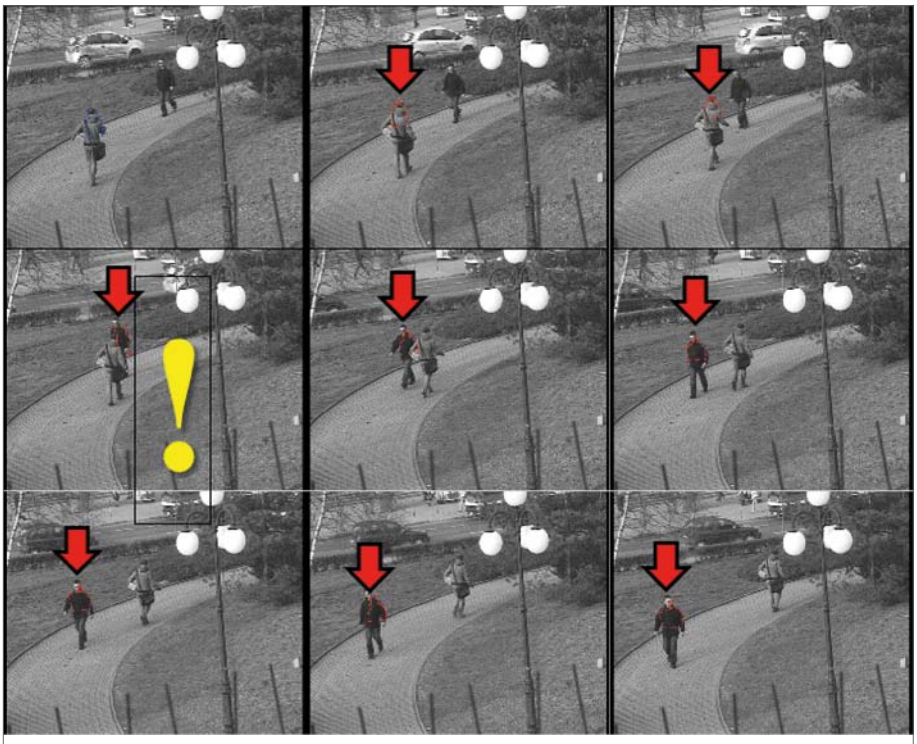

Fig. 6. Mistake during automatic person tracking [6]

Person reappearance detection

Last presented here goal for the automatic intelligent monitoring system taken into account in this paper is person re-identification problem in the surveillance application [4]. First problem is matching people across disjoint cameras. Given a query person image (usually called probe), person re-identification tries to identify the correct person object in a huge amount of candidate persons images (usually called gallery) captured by different cameras. Solving of such problem allows monitoring of particular person behavior in many parts of large-scale spatial region covered by multiple non-overlapping cameras. Let consider also another scenario: Behavior of one of many persons visiting restricted area during every appearance in observed space is apparently not suspicious. But fact, that the same person visited many times monitored space and penetrated systematically different part of this space – may be dubious. Intelligent policeman can discover this fact and can prevent results of this penetration, but how to solve similar problem using only automatic methods?

First we must solve person re-identification problem. It is special kind or object retrieval problem, where final recognition result purely based on a unidirectional matching between the probe image and all images from permanently registered person gallery. However this problem is very hard for practical solution due to person appearance changes caused by variations in illumination, pose, viewpoint and occlusion. Computer system must solve problem represented on figure 9, where the same persons are shown in upper and lower part of the image in different conditions.

For solving presented problem computer system must perform multi-matching procedure between captured image of suspicious person and all persons located in gallery, where images of all persons observed in previous time are located and stored. Dimension of the gallery is very big, therefore matching procedure must be very fast. At the same time matching algorithm must be very reliable for minimization of false alarm probability. General idea of such algorithm is presented on figure 10, but practical realization of this idea is still very far.

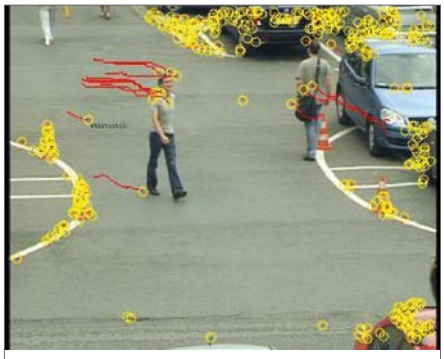

Fig. 7. Representation of person moving in form of couple of trajectories of selected points [6]

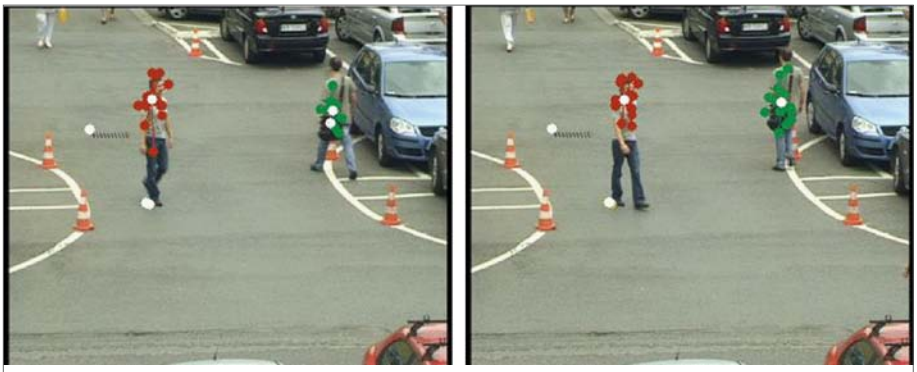

Fig. 8. Tracking of particular persons using method based on localization of characteristic points [6]

Fig. 9. Person re-identification problem is very hard for solving (images taken from the publicly available VIPeR data set) [4]

Fig. 10. General idea of person re-identification problem

References

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