Tracking Movement Target by Using WebGIS on Video Surveillance System

Ji Bin[1(✉)], Xu Ting[1], Zhao Chuanxing[2], and Chu Yuezhong[1]

[1] School of Computer Science and Technology, Anhui University of Technology, Ma'anshan 243032, China
I.1302793683@qq.com
[2] Department of Network Engineering, Anhui Normal University, Wuhu 241000, China

Abstract. This paper addresses a novel video surveillance system based on camera monitoring network. The system is belong to the application layer of Internet of Things (IoT). In the system, all videos are mapped into the corresponding camera nodes on a WebGIS (Web geographic information system). A group of the related nodes can be attained automatically by the Nearest Neighbor search method. In the searched node, the target can be automatically found in the video by target detection algorithm based on clothing color, and tracked based on particle filter. When above searching works are finished in an interesting geographical area, a completed movement path of the target can be displayed on the map, meanwhile, an information summary table about the target's current location, current speed, current time and event's attribute can be created. It also automatically collects the target's relative video clips for improving the artificially monitoring work efficiency.

Keywords: WebGIS · Object tracking · Valuable video clips · Video surveillance system

1 Introduction

IoT applications has been being widely adopted [1, 2], which is becoming more intelligent. Its effects have been making incredible strides as a universal media solution for the many scenarios. In the near future, a large number of daily objects with computing and communication capabilities will be interconnected using standard Internet protocols [3, 4], and data collection and processing speed will be a challenge or a new perspective for us [5]. In the platform of IoT, intelligent video surveillance technology [6] has been quickly becoming a hot research and accessed wide attentions.

The video surveillance system can be regard as a perception layer of the cameras monitoring IoT. The coverage scope of the cameras monitoring IoT has been growing. With the increasing number of videos, the followed problem is that the efficiency of searching manually an interesting target is extremely low. Therefore, the searching task is encountering unmanageable troubles. However, with the development of the safe city's projects, the video surveillance system is playing increasingly an important role [7]. In the other hand, under the rapid development and extensive application of GIS [8, 9], the video surveillance system based on the GIS is becoming a more and more pressing need,

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because videos can provide the objective motion and its location information in this field. Simon Denman [10] introduced a automatic surveillance in transportation hub which demonstrated target's performance on airport surveillance data. But this system can't show the movement path of the target within the geographic area. Bouwmans and his team [11] introduced the background detection technology from background modeling and pedestrian detection in terms of target recognition and tracking algorithms. Yilmaz, Wang [12] described the target tracking algorithm in detail from single camera and multi-cameras tracking. The works listed above are mainly limited to the single-source video, and the videos searching based on nodes network is still a difficulty. Therefore, an intelligent video surveillance system integrated WebGIS is quite promising.

This paper focuses on the design and implementation of the intelligent video Surveillance system from the perspective of human-computer interaction. It not only records the information of target's moving path on the map of WebGIS, but also automatically extracts the interested video clips included the suspect target. It improves the working efficiency for the monitoring staff.

2 Development Environment and Business Solution

2.1 Development Environment

This design uses the Linux operating system, which is a free and open source UNIX-like operating system. Firstly, Linux system can be more convenient because of using some lightweight and efficient open source software. Secondly, this design uses the computer vision technology with the OpenCV library to process the monitoring videos. Thirdly, this design uses Qt Creator for the preparation of human-computer interaction interface, which is a cross-platform C++ application framework and provides application developers to build art level graphical user interface. It is easy to extend and allow true component programming. It is a completed C++ program development framework and has a high degree of support for C++.

In summary, the design of the development environment:

Hardware platform:
CPU Intel Core i5-3210 M 2.50 GHz
Memory: 8 GB Kingston DDR3 SDRAM 1600 MHz
Graphics: Intel HD Graphics 4000 (2.13 GB)
Software platform:
Operating system: Fedora2.0
The program framework: Qt5.3.1
Integrated Development Environment: Qt Creator
Machine Vision Library: OpenCV2.4.7

2.2 Business Solution

This paper focuses on the intelligent video monitoring system based on the camera network map. The main research contents include the analysis about target state, cross-regional tracking, and the extraction of valuable videos. Based on the open source OpenCV machine vision library and WebGIS technology, this design realizes the functional requirements. The whole business's flow chart is as followed in Fig. 1;

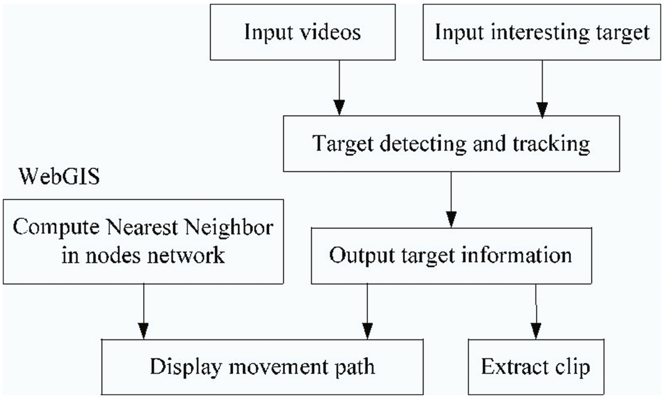


Fig. 1. Flow chart

The following topics should be explored in this paper.

1. Studying the recent moving target recognition algorithms and tracking algorithms and explore their advantages and disadvantages. We have studied the related algorithms and selected the algorithm which is suitable for the system, some of the algorithms should be modified to make them adapt to the demand of this system;
2. Studying the application of map information system services. We have called the Baidu map API using HTML language to write the appropriate codes and made the target move paths in the monitoring network;
3. Researching the continuous tracking algorithm in the multi-camera scenes. We have implemented the target cross-video analyzing and tracking in the monitoring network by the use of multi-threaded approach;
4. Studying the method of extracting valuable video clips. We have applied the corresponding cutting tools and download tools to extract the useful video clips from the video library, and achieve the function of 'preview,' 'save';

3 Using WebGIS

In recent years, GIS (Geographic Information System) has achieved increasingly wide application. WebGIS is the combination of Internet technology and GIS technology which is the GIS application in the network environment. From any node on the IoT, users can browse WebGIS map data and analyze spatial information. Web map service is becoming widely popular based on mature Web technology, computer technology and GIS technology. With the opening network technology, famous Online Map Service Providers almost welcome the third party softwares call their Map API in other applications.

This paper uses WebGIS (Baidu Map) API. In order to facilitate the user to search valid camera nodes in the map, we embed Baidu Map Webpage into the program. Through the Baidu Map API function we connect the map and video data library. When anyone clicks the camera button, the system can automatically load and play the video data from the video server. When the target is found in the related nodes, the icon color triggers a change from gray to yellow. When the automatically searching task has finished in the region, the movement path of the target can be played directly on the map. The path result is as shown in Fig. 2.

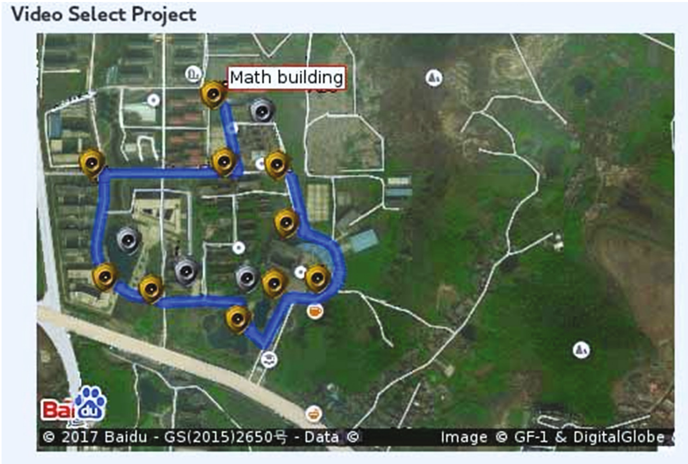


Fig. 2. The path on the Webcam Map

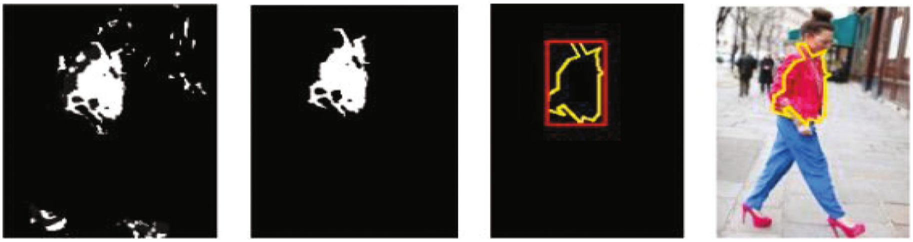
4 The Related Core Knowledge

4.1 Target Detection and Tracking in the Single Camera Scene

The process consists of two important steps: target detecting and target tracking.

In target detection algorithm, firstly we need obtain the feature of clothing-color by the operations of human interaction. After selecting body area of target, the color feature may be attained, and then, the similar color areas can be obtained by using a reverse projection method [13]. The clothing-color feature template is obtained after using region growing method [14] and contour of the lookup function [13]. This process of extracting the feature template is as shown in Figs. 3 and 4.

In target tracking algorithm, we use a particle filter tracking [15, 16] based on color histogram for target tracking. And its initial particle is the target which is identified by above target detection algorithm, and then according to the dynamic second order regression state transition equation to forecast the state of motion, the equation can be showed in formula (1):



(a) (b) (c) (d)

Fig. 3. The process of extracting the feature template about coat; (a) using reverse projection method; (b) using region growing method; (c) Extracting the outermost contour; (d) result of the contour

(a) (b) (c) (d)

Fig. 4. The process of extracting the feature template about underwear; (a) using reverse projection method; (b) using region growing method; (c) Extracting the outermost contour; (d) result of the contour

$$\begin{cases} X = A_1 * (P_x - P_{x0}) + A_2 * (P_{xp} - P_{x0}) + B_0 * gsl\_ran\_gaussian(rng, TRANS\_X\_STD + P_{x0} \\ Y = A_1 * (P_y - P_{y0}) + A_2 * (P_{yp} - P_{y0}) + B_0 * gsl\_ran\_gaussian(rng, TRANS\_Y\_STD + P_{y0} \end{cases} \quad (1)$$

The coefficients set as follows: A_1 = 2.0, A_2 = −1.0, B_0 = 1.0, *TRANS_X_STD* = 0.5, where *Px*, *Py* are the coordinates of the center of current particle position, Px_0, Py_0 are the coordinates of the center of initial particle position, *Pxp*, *Pyp* are the coordinates of the center of previous particle position, *gsl_ran_gaussian()* is gaussian distribution function to generate random numbers.

It can generates sampling points after above forecasting. Therefore, two histograms' color similarity of the predicting location and the initial position can be calculated by Bhattacharyya distance formula, which is as shown in formula (2) and (3):

$$\rho(\mathbf{p}, \mathbf{q}) = \sum_{i=1}^{N} \sqrt{p(i)q(i)} \quad (2)$$

$$d = \sqrt{1 - \rho(\mathbf{p}, \mathbf{q})} \quad (3)$$

In the above equations, the correlation coefficients are explained in Table 1;

Table 1. The correlation coefficients

q	The eigenvector of particle regions	$p(i)$, $q(i)$	The i^{th} eigenvalue of eigenvectors **q, p**
p	The eigenvector of the target template	N	The number of features
d	Bhattacharyya distance	$\rho(\mathbf{p}, \mathbf{q})$	Similarity coefficient

Fig. 5. The effects of single-camera scene in the target tracking; (a) 50^{th} frame; (b) 100^{th} frame; (c) 150^{th} frame; (d) 200^{th} frame; (e) 250^{th} frame; (f) 300^{th} frame

This Bhattacharyya distance is as weight. It can automatically adjust particle weight and modify the original boundary location according to the weight, which can falls on the target, i.e. target tracking is finished. Until the target disappears in a single camera scene, the whole tracking effects is as followed in Fig. 5.

4.2 The Search Method About Neighborhood Areas

All videos data need be mapped the corresponding nodes of monitoring IoT. In an interested geographical scope which is selected manually, each node where the target passes by should be found by using the nodes search algorithm. The flow chart of the algorithm is shown in Fig. 6. Firstly, a start node should be found after the man-machine interaction, then the video in the node can be detected whether there is a video segment with having the target. Secondly, this node is regard as a core node, the neighbor nodes round this core one will search the object in next one. If one of the nodes finds the target, the node continues to track the moving target until the target leaves this monitoring scene, meanwhile the rest nodes terminate searching. And this node will be regard a new core node for going on subsequent searching. The above operation is repeated, until the target leaves the monitoring region, meanwhile, the moment means the target detecting and the target tracking work over.

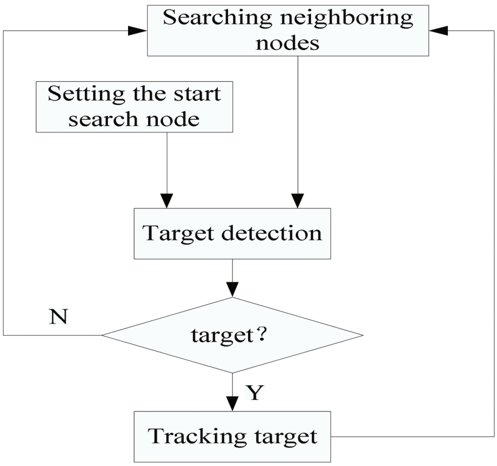


Fig. 6. The Search algorithm about neighborhood areas

The neighbor nodes round the core one are searched by the multi-threaded processing program inherited from the Qt with the base class QThread. Once one of threads finds the target, the others threads will be aborted.

The following code is a definition of this class:

```
class Tracer : public QThread
{
public:
    explicit Tracer(QObject *parent = 0);
    Tracer(QString filename, const CvScalar &color, int md = NORMAL, int bTime =
0);
    ~Tracer();
    void run();
    IplImage* getResultFrame() const;
    void stop();
    int getBeginTime() const;
    int getEndTime() const;
    int getCurrentTime() const;
    int getEndFoundTime() const;
    int getBeginFoundTime() const;
    float getSpeed() const;
    bool isFound() const;
    bool isInArea() const;
    QString getVedioName() const;
    QString getEvent();
•••//Since the content is omitted;
};
```

Qt performs thread operation in the thread class by rewriting the run () function. Here, the run () function implements a tracking algorithm, which has been described above in detail.

4.3 Results of Human-Computer Interaction Operation

Based on the above analyses;

(1) Achieving a movement target information record about a series of target's state characteristics in the monitoring video, including its current location, current speed, current time and event's attribute (to determine whether it's abnormal), as shown in Fig. 7;

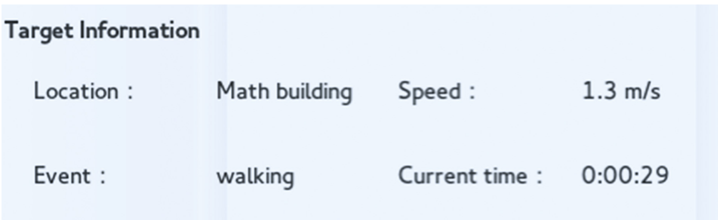


Fig. 7. Information record

(2) Forming a target information summary table after finishing the searching process of the target in the interesting monitoring network area, which includes the node's position name, the time of target's appearance, the time of target's disappearance and time span, as shown in Fig. 8, monitoring staff can preview and download these videos.

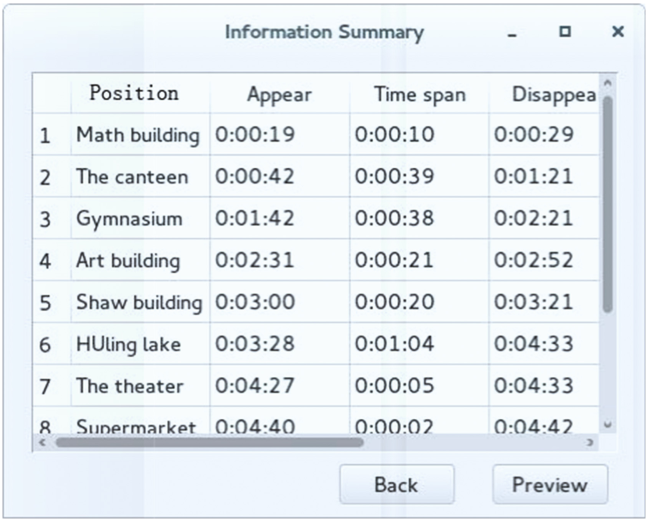


Fig. 8. Information summary

5 Summary

This design combines the video data on the camera nodes of monitoring IoT and WebGIS. In the specified geographical areas, it can search an interesting target. The system can extract of the corresponding nodes where the target passed by and show its moving path. By manually giving the target area, the system can intelligently detect and track the target, and summary the state information about the target, and provide the functions about preview and download target's video clips according to information summary table for police works.

This video surveillance system runs on the application layer of monitoring IoT. It combines the knowledge of specific industry and the scientific achievements. The application needs the support of intelligent information processing technology, which can analyze the monitoring area with having large amounts of videos. Simultaneously, it provides human-computer services through an interactive interface, greatly improving the efficiency of manual analyzing and tracking of the target.

IoT as an all-embracing technology has significant potential, social value and application demands in various applications [17]. Intelligentizing video surveillance system will promote the monitoring networks based on IoT.

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