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Research and implementation of key technologies for smart park construction based on the internet of things and cloud computing[1]

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Abstract. Smart park is an important manifestation of smart city. Its architecture and development pattern are epitomes of smart city in some scope as well as an important part of smart city development. The paper introduces the current development of the Internet of Things and Cloud Computing as well as an overview of smart park construction based on the two technologies, and studies and probes into the implementation model of smart parks based on the Internet of Things and Cloud Computing, focusing on the materialization of key technologies applied to smart parks including architecture design of the Internet of Things, isomorphic processing of isomerous data via middleware, application mode of cloud computing, intelligent monitoring and behavior recognition technology as well as intelligent push technology. The application of these technologies can remarkably increase the information management level and execution efficiency of smart parks.

Key words. Internet of things, Cloud computing, smart parks, key technologies.

1. Introduction

With the rapid development and in-depth application of new concepts and new technologies such as the global Internet of Things, smart planet, smart city, smart park, cloud computing and new-generation mobile broadband network, people are stepping into a digitized and networked intelligent society. Smart park is an important manifestation of smart city. Its architecture and development pattern are epitomes of smart city in some scope. The long outdated construction mode of traditional parks cannot provide sustainable guarantee for the construction of smart parks. In spite of independent development of all application systems of traditional

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parks, there is no effective sharing, interconnection and effective combination of information between these systems. Therefore, the application of modern advanced technologies becomes necessary in order to effectively improve the operation management level and service level of smart parks. For instance, the implementation of high intelligent data sharing and information centralized processing requires design and implementation of multi-layer application of the Internet of Things and core application of cloud computing; the implementation of isomorphic processing of isomerous data requires the application of middleware technology; and the enhancement of intelligent processing and decision-making of video-capture data requires the utilization of behavior recognition technology [1]–[2].

2. Construction overview and architecture of smart parks based on the Internet of Things and cloud computing

Smart parks can not only bring about changes in the scope of concept but also make huge and far-reaching changes in areas such as production mode, pattern of life, exchange mode, public service, institutional decision-making, planning management and society and people's livelihood. Features of smart parks can be summarized with three words: perception, interconnection and intelligence. Perception: in smart parks, the status of important management objects of all systems can be accurately perceived and measured through the application of advanced technologies such as the Internet of Things. Interconnection: the application of high speed communication and network within smart parks enables efficient interconnection between relatively independent systems and departments, increasing communication efficiency and forming efficient ecological structure of the parks. Intelligence: intelligent autonomous management of smart parks can be materialized by constructing various smart application systems within the parks; effective multi-aspect, multi-angle and all-round analysis, judging and forecasting can be implemented by integrating and combing information from all sources based on cloud computing, business intelligent processing and other related technologies, and then improve intelligent decision-making oriented to internal and external management of the parks.

Currently, the construction of smart parks in China should start with breakthroughs in four aspects, namely limited design, fragment information, hollow construction and fragile security. Therefore, the proposal of a solution of intelligent information system based on the concrete application of the Internet of Things, cloud computing, big data and other new generation information technologies enables real-time perception, extensive interconnection and intelligent analysis at higher levels.

The ultimate goal of smart parks is to change the interactive mode between the government, enterprises and residents with abundant smart services and to realize more intelligent operation of the parks. Smart parks adopt the model of "smart city", and the overall construction structure is shown in Fig. 1, including perception layer, network transmission layer, platform layer (cloud computing application layer) and application layer [3]–[5].

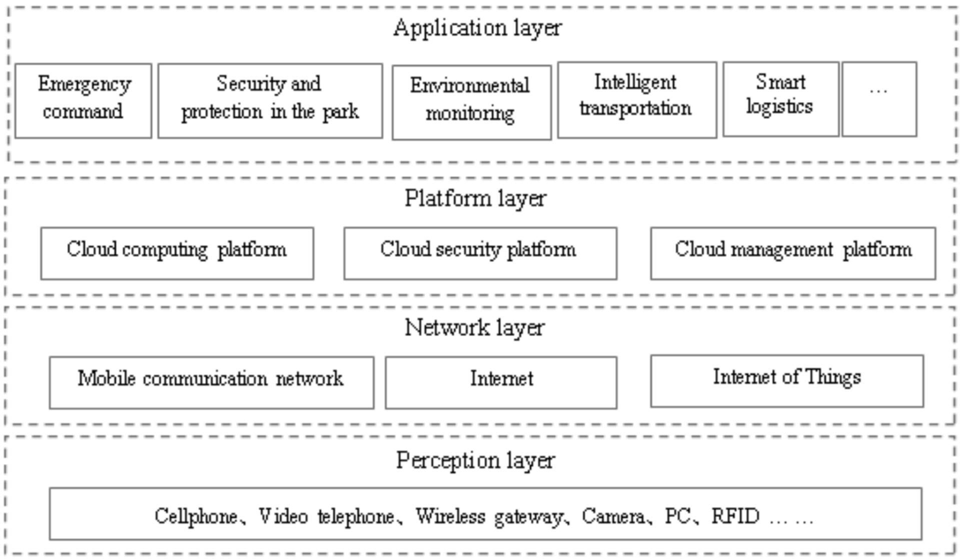

Fig. 1. Overall architecture of smart parks

3. Key application technologies and realization of smart park construction based on the Internet of things and Cloud computing

3.1. Architecture design of the Internet of things

According to the overall architecture of smart parks, the system of the Internet of things is composed of the perception layer, the network layer and the application layer. Information transmission between layers thereof is controllable, interactive rather than unidirectional, as well as diversified. The most crucial information is the information of things, including the static information, the dynamic information and the ID code which is the only identification of things within certain application systems.

The application of the Internet of things, the core technology of smart park construction, enables the construction of a neural network covering every inch of the park and makes data easily acquired. As one of the core technologies of the Internet of things, mass information intelligent processing can carry out mass storage of various information of the Internet of things, conduct rapid processing and report the results back to every control unit of the Internet of things. Many applications and industries based on the Internet of things play a dominating role in the constitution of smart parks. The application of the Internet of things is indispensable for the construction of smart parks for it builds the skeleton of the smart park system.

3.2. Realization of multisource data integration middleware

There are various data access modes and interactive modes during data acquisition of the Internet of Things applied in smart parks; besides traditional structured data like various databases, some non-structured data will also interact between public network and LAN frequently, making big difference in the definition format, data storage mode and data transmission mode of different basic data, in other words, there are numerous heterogeneous data sources. In addition, data also contain tremendous sensitive information in the process of transmission, while such information is good carriers of virus and Trojan Horse. Thus, a middleware is required to be constructed, which should, on the basis of satisfying the information transmission security requirements, adapt to all kinds of multisource data formats, meet the demand of big data volume and complete the consistence maintenance of data, so as to provide data exchange inside and outside information network reasonably.

With middleware technology, it is possible to extend various protocols, data formats, information forms and filtering algorithms flexibly. Therefore, to research the technology portfolio of multiple security filtering methods based on standard middleware, it is acceptable to combine filtering based on grade labels, which based on protocols, that based on data features and that based on intelligent content aware flexibly and realize isomorphism treatment of data upon completion of security filtering.

The middleware architecture of multisource data exchange is consisted of functional modules like drive module, receiver module, global filtering middleware, configuration management and monitoring management. After pretreatment by drive, multisource data are attached with label information by use of private protocol and sent to the isolated service receiver module via encrypted channel; via the isolated service receiver module, data of heteromerous and heterogeneous sources are sent to XML as data in virtual data warehouse and then as standard data after interaction in XML format. After access to and treatment in the security filtering center, data are exchanged to the target document server.

The said middleware architecture can realize secure data exchange between business system and document server, with the former to be the initiator of exchange and the latter to be the data receiver. The said middleware can realize bi-directional data exchange, with data exchange request possible to be initiated both in public network and in LAN. The difference lies in that the data exchange from inside to outside mainly focuses on data loss prevention while that from outside to inside on filtering of malicious files.

3.3. Materialization of intelligent monitoring and behavior recognition

There are more and more video capture sources in modern monitoring systems, especially in industrial parks. In order to avoid monitoring dead angles, the number of cameras and other data acquisition equipment should be increased. However, the severe lack of monitoring management staff on duty and failure in configuration of excessive displayers make it impossible to meet the requirement of real-time monitoring even with the help of switchover equipment, hence making it necessary to add "intelligent behavior analysis system" based on cloud storage and cloud analysis in key positions to conduct early warning of abnormal behaviors of traffic and staff in the park. For example, when detecting traffic jams or traffic accidents in the park, the system sends out alarm message directly to staff on duty to warn him to pay attention and dispose accordingly. This avoids the "blindness" of the staff on duty after long-time observation of images and then remarkably improves the utilization efficiency of the information system in the park. Therefore, with increasing attention to security, intelligent video monitoring technology and behavior recognition technology have currently become research hotspots. Intelligent video monitoring includes the detection, classification, tracking and recognition of appealing targets in dynamic scenarios in the bottom layer and behavior recognition, analysis and understanding of appealing targets in the high layer. Intelligent video monitoring technology is extensively used in various monitoring scenarios such as public security monitoring, industrial site monitoring, residential quarter monitoring and traffic condition monitoring in order for crime prevention, traffic control, accident prevention and detection, custody of the old, the young the sick and the disabled as well as other purposes. It can greatly increase monitoring efficiency and reduce cost, guaranteeing comprehensive research significance and application prospect. Hence, the utilization of intelligent monitoring and behavior recognition in smart parks can remarkably improve the perception power, judging ability and decision-making capacity of the park [6]–[7].

3.3.1. Intelligent video monitoring algorithm framework. The main content of intelligent video monitoring research is how to extract semantic comprehensions conforming to human cognition from original video data, i.e. expecting the computer to automatically analyze and comprehend video data like human beings. For example, it can find out appealing targets in the scenario, their throughout movement track, their behavior, the relation of the targets, etc. Generally speaking, the processing of video images in intelligent video monitoring research can be divided into three layers as shown in Fig.2.

Bottom layer. This layer mainly acquires image sequences from video image acquisition terminals and detects and tracks appealing targets, so as to facilitate follow-up processing and analysis of targets. It solves the problem of where the target is. Target detection can be divided into target modeling and background modeling. Target tracking aims to obtain the activity time, location, movement direction, movement speed, dimension and appearance (color, shape and texture) of moving targets and it falls into two categories: single-scenario target tracking and trans-scenario target tracking.

Middle layer. This layer mainly extracts various information of moving targets and conducts relevant judgment based on the bottom layer. It mainly contains target recognition aiming to classify targets before identify them and can be divided into target classification and individual recognition. The analysis of the middle layer builds a bridge between bottom layer processing and high layer behavior compre-

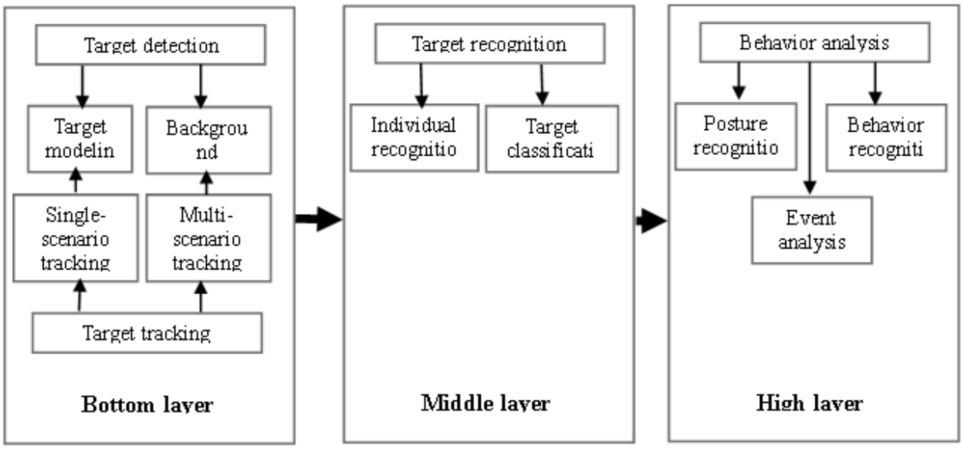

Fig. 2. Intelligent video monitoring algorithm flow

hension and fills the semantic gap between the bottom layer and high layer. This layer mainly solves the problem of what the target is.

High layer. The high layer processing completes analysis and understanding of target behavior. High layer semantics implies certain semantic scenarios and usually has a close relation to specific applications. Behavior analysis can be divided into posture recognition, behavior recognition and even analysis and it mainly solves the problem of what the target is doing.

3.3.2. Target detection. Target detection means to extract the movement foreground or appealing target from videos or images, i.e. to determine the location of the target in present frame at present moment and its size. So target detection plays a basic role in intelligent video monitoring algorithm, and its performance has a direct impact on the algorithm of follow-up target tracking, target classification and recognition.

Target detection can be divided into two categories: moving target detection method based on background modeling and detection method based on target modeling according to different data objects to be processed. Detection method based on background is only applicable when the appealing target is constantly motional in the same background. When background changes, such method will mistakenly detect the changing background as movement foreground and then classify it as background after the target stops moving for some time. Therefore, such method is not applicable for scenarios with changing background, such as those shot with handheld cameras and on-board cameras. This method can normally meet the requirement of real-time detection and therefore is extensively used in applications employing fixed cameras.

With its foreground extraction method free from the limitation of application scenarios, detection method based on target modeling can not only conduct appealing target detection of videos shot by fixed cameras but also handle single frame static images and videos shot by moving cameras. The huge number of windows to scan results in relatively low detection speed that fails the requirement of real-time detection, making the method hard to be applied in practical systems requiring real-time detection. The comparison of the two methods is shown in Table 1.

Table 1. Classification of target detection methods

Feature	Method based on background modeling	Method based on target modeling
Source	Video	Image video
Target	Motional	Static/motional
Background	Fixed	Fixed/moving
Algorithm speed	Fast	Slow
Influence of shelter	Slight influence	Big influence, apt to decision emission

3.3.3. Target tracking. Target tracking aims to determine the consecutive location of the appealing target in video sequence, i.e. to determine "where" the target is. Target tracking is a basic problem in computer vision field as well as an important link of intelligent video monitoring with high value of broad application. Target tracking can record the throughout movement track and movement parameter of appealing targets which lays the basis for target behavior analysis and comprehension in higher levels.

Target tracking algorithm can be divided into single-scenario target tracking and multi-scenario target tracking according to different application scenarios. The former contains single-target tracking and multi-target tracking while the latter can be divided into overlapping scenario target tracking and non-overlapping scenario target tracking. Table 2 is the summarization of features of single-scenario target tracking algorithm, overlapping scenario target tracking algorithm and non-overlapping scenario target tracking algorithm.

Table 2. Classification and features of target tracking algorithm

Feature	Single-scenario target tracking	Overlapping scenario target tracking	Non-overlapping scenario target tracking
Time/space	Both continuous	Continuous in time	Both having large gaps
Time synchronization	-	Required strictly	Required
Demarcation of camera	Not required	Generally required	Not required
Tracking scope	Small	Big	Huge
Influence of shelter	Serious	Slight	Serious
Application scope	Generally applied	Special occasions	Generally applied

For example, in single-scenario target tracking, the spatial locations of the same target in two consecutive frames are very close; in overlapping scenario target tracking, when a target moves from one scenario into another through the overlapping scenario, the target identification in the new scenario can be determined by virtue of continuous spatial relations; in non-overlapping scenario target tracking, the existence of dead zones between two scenarios results in big difference in terms of time and space between observations of the same target in different scenarios.

3.3.4. Behavior analysis. Behavior analysis targets what the behavioral agent is doing by virtue of computer visual information (image or video). Comparing to object detection and classification, human behavior analysis is the realization of a higher-level target, relates to a deeper understanding of human visual system and is one of the ultimate problems to be solved in the field of computer vision. Besides its theoretical research value, behavior analysis also carries a prospect of extensive application such as that in man-machine interaction, intelligent video monitoring, smart home and video retrieval. Behavior analysis method can be divided into static posture recognition method, motional behavior recognition method and complex event analysis method according to the complexity degree of information supply as shown in Fig. 3. Static posture recognition method takes static images as its research object and conducts classified recognition of human posture based on image detection and recognition methods. The research objects of the latter two behavior recognition methods are based on video sequences.

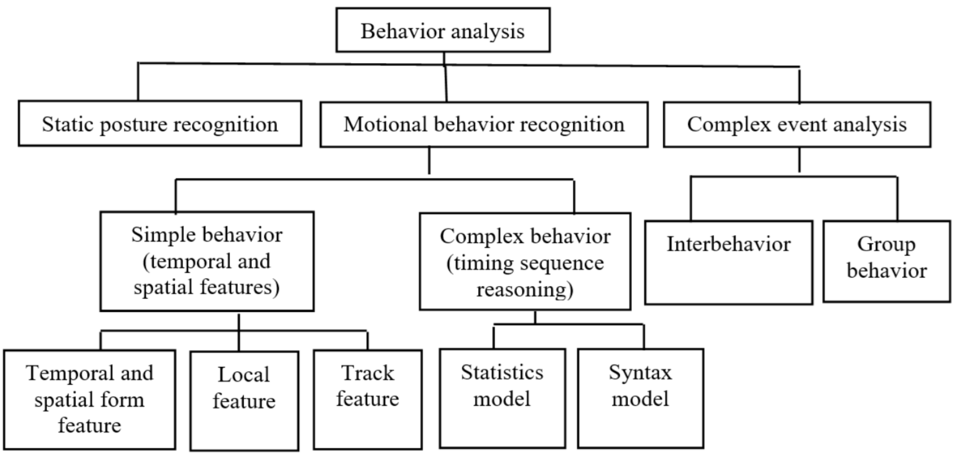

Fig. 3. Constitutional figure of behavior analysis

4. Conclusion

This paper proposes the application and realization of key technologies based on the Internet of Things and cloud computing in smart parks. The application of design of multi-layer architecture of the Internet of Things, design of multi-source data formation middleware, cloud computing technology, intelligent monitoring and behavior recognition technology as well as intelligent push technology will greatly improves the information management level and execution efficiency of smart parks.

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