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An Intelligent Detection Approach to Multi-Intrusions Based on Hybrid-model Searching Algorithm

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***Abstract*—In this paper, an intelligent detection system for multiple intrusions for smart home is presented. In the developed system, home users equipped with PDAs may locally and remotely receive the alert of home intrusion with captured subject image. There are three key components developed in this system. One is the intrusion image processing (IIP) to recognize the intrusion and extract the intrusion subjects. The second is a hybrid-model searching algorithm to improve the accuracy and computation cost in searching intruding subjects. The third is the Universal-Plug-and-Play (UPnP-based) instant messaging (UIM). Through the integrating of the three software component, intelligent intrusion detection is capable of offering a smart home security system. The implementation results show that the presented system at most identify three intruding subjects with at least 80% accuracy better than the previous works.. The presented system demonstrates a smart and automatic solution in comparison with legacy approaches**

***Keywords*—Multi-intrusion detection system, Home Security, Image processing, UPnP, Hybrid-model Search Algorithm.**

I. INTRODUCTION

As the evolution of information and communication technology (ICT), the high-speed computation and networking have made a smart home living real and practical. Today ICT not only serves with the industrial and academic people but also benefits the residential users in the fields of education, entertainment, commerce and even security. According to the report from Digitimes [1], the production value of global digital home industrial in 2008 will be USD 5 thousand millions. Obviously, the ICT products have essentially involved in people daily living [2-3]. The new digital home appliances definitely help people to easier and faster grasp information and knowledge through sensor devices and networks. Certainly, the introduction of ICT technology also facilitates the development of home security service. Since the home security is always a significant issue of real living about how to detect the danger, malicious activities and prevent people from injured/risk, the applying of ICT technology to improve the security of home user is the target problem investigated in this paper.

In the past, there were lots of works about the deployment of sensor networks to detect the intrusion behavior [4-6]. Although the sensor deployment is helpful to the home security, the deployment is costly and exhaustively. Traditionally, cameras have been widely used to collect and monitor the image of the target area. However, there are some problems in this approach; (1) the intrusion can not be detected immediately, (2) the storage has to be huge to maintain image information (3) no friendly user interface is available. Thus the work presented in this paper is to solve the problems and to provide a feasible and efficient approach to enhance the home security.

The rest of this paper is organized as follows. The related works are presented in Section 2. In Section3, an intelligent detection approach to multi-Intrusions based on hybrid-model searching algorithm is proposed to illustrate the architecture, methodology and functionality of this work. The performance evaluation is described in Section 4. Finally, we conclude this work in Section 5.

II. RELATED WORK

In this paper, there are two key technologies utilized to implement the home security system; image-based intrusion detection and Universal Plug and Play (UPnP) [7-8]. First, we will explore the related works presented be-fore about the detection of the intrusion image in a home environment. Motion estimation is the key to intrusion detect problem. So far, there are lots of approaches, including Exhausted Search Algorithm (ESA) [6], Three-step Search Algorithm (TSSA) [7] and Diamond Search Algorithm (DSA). The search algorithms are designated to find the best-matching block from the current frame. Through the best-matching block relationship between current frame and reference frame, the motion vector of an object is obtained. The motion vector is significant in finding the intrusion object. ESA is the basic approach to find the best-matching block. However, the search time of ESA is proportional to the square of the image width and height. As a result, ESA can not be applied on real-time application such as surveillance. TSSA improves the slow response of ESA because TSSA applies a coarse search first, then two-level finer searches are conducted to make the block-matching better. TSSA sometimes per-forms a faster search but the accuracy of block-matching is not guaranteed. Diamond search (DS) [8-9], cross-diamond search (CDS) [10] and adaptive rood pattern search (ARPS) [11] are some more recent well-known algorithms, but they are proposed for single-frame motion estimation only. Directly applying them to multiple frames cannot sufficiently exploit the temporal correlation in long frame sequences. In this paper, a hybrid search approach, called as HSA, is proposed to compromise ESA and TSSA to adjust the search granulity to meet the requirement of real-time and accuracy. UPnP is an essential to enable an automatic configuration of home devices. UPnP technology has the significant functionalities to facilitate a premium digital living;

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(1) automatic configuration and interconnections of home devices, (2) automatic service discovery, (3) easy access of service content, (4) flexible association between home devices. A typical UPnP network usually is composed of three components denoted as Control Point (CP), Server Point (SP) and Renderer Point (RP) as shown in Fig. 1. The function of CP is to offer the user interface for users. SP is operated on content servers to receive service requests from users and to deliver service contents to users. RP receiving the service content from SP renders the content in specific output devices for users. Consider an example as follows. In a home multimedia service, the home user uses a PDA as a CP .Through the CP, user may query service contents on media servers as a SP and select a preferring content from the content list given by SP. The selected content will be delivered to a media player as a RP and be replayed for the user.

UPnP employs TCP/IP to deliver messages and con-tent data between its components. Based on TCP/IP, there are HTTP, SSDP, GENA and SOAP collaborating to offer the functions of device addressing, device discovery, content description, action control, event notification and content presentation. HTTP is in charge of exchanging control and eventing messages between points. Extensible Markup Language (XML) is the message format used here. SSDP (Simple Service Discovery Protocol) enables the function of service discovery for new-attached devices. The new-attached devices broad-cast a SSDP message to search possible UPnP devices. The existed UPnP devices reply the search message ac-cording to SSDP. GENA (Generic Event Notification Architecture) is a mechanism of transmitting and receiving event messages in service duration. SOAP (Simple Object Access Protocol) is designed for the management of remote procedures, including the folk, execution and termination of remote procedures. In UPnP, SOAP is utilized for CP and DP to manage the accesses of service contents on SP. One thing should be noticed is the XML-based message. XML is a well-defined and common-used message format due to its extensibility. XML messages designed for UPNP applications support the information exchanges of device/service description, control message, eventing and action. Thus these compose a kernel data structure of UPnP applications.

In the area with UPnP-enable devices, either CP or RP issues a SSDP notification to SPs in this area when they are entering. Then CP will acquire a description file in XML from preferred SP to find the available service contents on servers. Afterward, CP sends SP with a SOAP message to request service content. When the re-quest is acknowledged by SP, a URL to access the target service is forwarded to RP and the RP will acquire the service content. During the rendering of service on RP, RP notifies CP and SP with events if the status of RP is changed. The operations of UPnP devices are classified as follows,

(1) Addressing: The addressing of UPnP devices is to obtain their unique IP addresses. It usually is done by DHCP servers or Auto-IP.

(2) Discovery: On the entering of devices to a service area, the devices issue a broadcasting SSDP notification to the other devices existing in this area. Via this broadcast message, CP will be aware of the statuses of the existing SP and RP and control them.

(3) Description: All messages exchanged between CP, SP and RP are presented in XML syntax. The ex-change of XML messages is implemented by HTTP protocol.

(4) Control: Control actions are issued by CP to either SP or RP. CP uses control actions to select the con-tent server and the preferred content and the specific RP as the player to render the content according to user instructions.

(5) Eventing: The eventing is used to notify the related devices when the status of a device is changed. For example, an eventing of content run-out will be sent by RP to CP when the replaying of a media clip is ended,

(6) Presentation: RP is in charge of service content presentations. For examples, in multimedia service, RP is the media player to replay the media; and in home appliance control, the power switch is the RP to realize the desired output of users.

Based on UPnP protocol, we develop an automatic alerting system. When the user with a hand-held device, such as PDA, enters the monitored house, the hand-held de-vice will automatically connect a home gateway to retrieve key frames of possible intrusions.

III. MULTI-INTRUSIONS DETECTION BASED ON HYBRID-MODEL SEARCHING ALGORITHM

The application scenario is illustrated in Fig. 1. In a home environment, the webcam continuously monitors the target area and capture the image sequence for processing. The captured image sequence is delivered to the server and is processed according to the procedure as shown in Fig. 2. Once a intrusion is detected and the intruding object is locked, the key frame is marked and an alerting message is sent via SMS (Short Message Service) to the users. When the user is back to home, the hand-held device of user will connect automatically to the server and obtain the key frames from server.

The developed software components are a server module and a client module. The server module is designated to (1) acquire the capture image sequence; (2) analyze the captured image sequence; (3) detect the intrusion; (4) extract the key frame of intrusion and (5) deliver the message to the users. Thus, the server module deals with the effective image processing and the alerting mechanism. The client module is to offer a friendly user interface of hand-held device. The design details of server module and client module are described as follows.

The server module consists of six operations: (1) image capture, (2) image transform, (3) image subtraction, (4) image filtering, (5) intrusion detection and (6) intrusion tracking. The most significant operation is how to detect the intrusion and track it. After the image capture, transform, subtraction and filtering, the possible intruding object is denoted by the region of high-intensity pixels. From an image sequence S = {Ii, for i = 0, 1, ..}, a sequence of image difference D = {di= Ii,- Ii-1,I, for i = 1, ..} is obtained by successive image subtraction. The

determination of the positions of intruding object in successive image sequence is defined as the tracking problem. The tracking problem is solved by the block matching of image blocks of intrusion and to obtain the motion vector of the moving intruding object. In this paper, hybrid-model search algorithm (HSA) is proposed to find the position of the best-matching block in the current frame and to find the motion vector of the intruding object. The algorithm of HSA is presented as follows,

Step 1. Find the location of the best match of marco-block in reference frame to obtain the origin of macro-block

Step 2. Half the value S and find the location with the minimum error as the new origin of the macro-block.

Step 3. Repeat Step (2), until S = 1.

Step 4. Set S=2, use ESA to search the macro-block in reference frame till the match with minimum error is the best match B^{best}. In other words, the best match is obtained according to the following objective function

$$B^{best} = \underset{x,y}{Min} \mid B^{i}_{x,y} - B^{i-1}_{x,y} \mid \qquad (1)$$

The proposed hybrid-model search algorithm, the match accuracy and search time are balanced and improved simultaneously. Making use of the proposed algorithm, the operations of the multi-intrusion detection are stated as follows,

Step 1. Detect the intrusion subject in a new frame.

Step 2. If no intrusion is detected, back to Step. 1

Step 3. Mask the subject region in black blocks.

Step 4. Estimate the motion vector of the intrusion subject and update the mask region accordingly.

Step 5. Detect the intrusion subject in the residual region

Step 6. If another intrusion subject is detected, go to Step 3. otherwise go to Step. 4

The operation of the client module is as shown in Fig. 3. When user is outsides from home, the alerting message is instantly sent through SMS. When the user is back to the house, the UPnP function enables a sequence of automatic network connection, service content discovery, acquire the alerting message, retrieve the key frame of the intrusion and access the tracking record of intruding object. Horng [5] solved the problem of single-intrusion detection. The multi-intrusion detection is manipulated as follows.

Step 1. Derive the motion estimation given as

$$D = \sqrt{(dx)^2 + (dy)^2} \qquad (2)$$

where (*dx , dy), D* are the displacements vector of the possible intrusion and the motion estimation in two successive image frames, respectively.

Step 2. If the estimation is greater than the threshold *T* , the detected marco-block is regarded as an intrusion and is denoted as I_i.

Step 3. Mask the marco-block detected as an intrusion. Repeat Step 1 to find the next intrusion.

Step 4. If the new-detected intrusion I_{i+1} is overlapping with the previous detections, the overlapped intrusions are merged as one intrusion.

Step 5. Go to Step 1.

In comparison of single/multi-intrusion detection, the algorithm of multi-intrusion detection works in the cases of independent intrusions, occluding intrusions and overlapping intrusions. In such a case, the accuracy of HMSA is better than TSSA due to the fine-tuning searching contributed by HMSA. Through UPnP-enabled client module, home user can easily and timely be aware of the security of the home environment. This presented system is implemented to verify the system effectiveness and efficiency. The details of the experiment results are illustrated in the next section.

IV. EXPERIMENTAL RESULTS AND ANALYSIS

To verify the performance of the proposed system, a series of experiments is set up. The experiment environment is depicted in Table1. The server module is based on MATLAB and Intel UPnP toolbox. The client module is developed by J2ME tool. The background of the testing image is with complicated real background with no assumption. Just as a real world, most back-ground is complicated and colorful. Thus the images with complicated backgrounds are also verified in experiments. The intrusion subject is two walking persons in the monitored space. When the person is detected, the subject is be marked by a rectangle and a SMS with the key frame is sent to a pre-assigned mobile phone. One of experimental results is illustrated by Fig. 3. The results show that ESA has the best detection rate (12/12 = 100%) but TSSA has a fault detection out of 12 trials (11/12 = 92%). The proposed HSA demonstrate premise results similar to ESA. In the testing image sequence, the two persons randomly walk in different directions and their walking trace is intersected. In this scenarios of twelve frames, EAS has two false detection and a detection miss, thus the correct detection rate is 9/12 = 75%. And TSSA has three false detections (9/12 = 75%). But the pro-posed HSA has a better true detection performance (11/12 = 92%). According to experimental results, the HSA has been shown with its good performance in intrusion detections.

Then, we also evaluate the performance of three search algorithm; ESA, TSSA and HSA, to detect the people movement in a real background. The performance of execution time is depicted in Fig. 4. After the performance evaluation of intrusion detections, the alerting of detected intrusions is also demonstrates as follows. The client module developed on a Mobile phone (Nokia N81) is to receive the UPnP alerting message from the server. Once an intrusion is detected, the server will send a SMS message to the user. The testing results of UPnP alerting message are shown in Fig. 5. The mobile phone is notified to receive and shows alerting messages delivered through UPnP protocol, when the user comes back to house. The captured key frame is displayed on the mobile phone as depicted.

TABLE I. EXPERIMENTAL ENVIRONMENT

Server Specification	
CPU	Intel® Core™2 Duo CPU E6550 @2.33GHz
Memory	1GB RAM
OS	Microsoft Windows XP Professional SP2
UPnP tools	Intel_Tools_4UT_v1788
Image Processing tools	Matlab 2007a
WebCam	Logitech WebCam
Client Specification	
Hand-held Device	Nokia N81
CPU clock rate	369MHz
OS	Symbian S60(3rd Edition)
Developer Environment	J2ME MIDP 2.0
Image Specification	
Resolution	640*480
Search regien size	Pixel = 7
Macro block size	16*16
Search Algorithm	ESA、TSSA、HMSA

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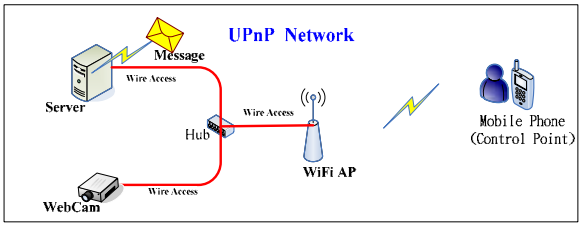

Figure 1 Example of a figure caption.

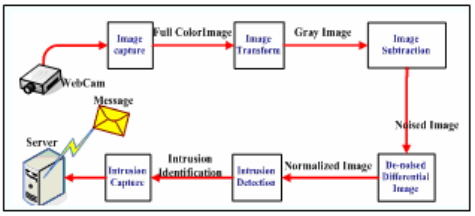

Figure 2 Operational procedure of the proposed system.

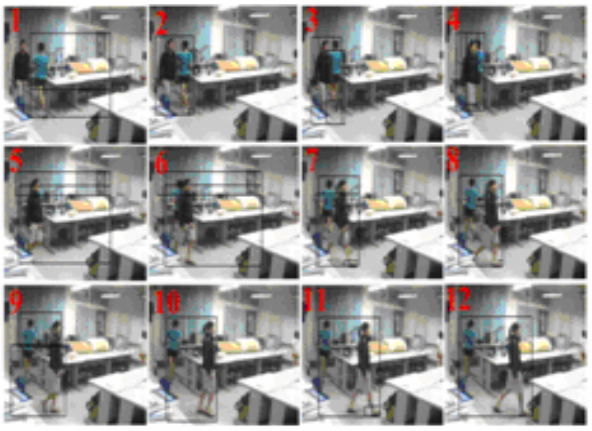

Fig. 3 Image sequence for tests in complicated background

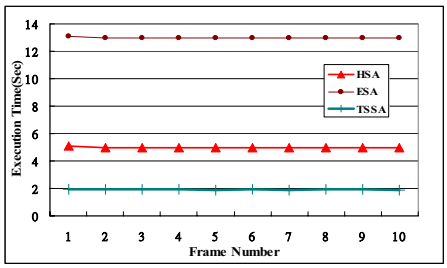

Figure 4 Comparison of block-matching by ESA, TSSA and HMSA


Fig. 5 An alerting message with a key frame