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

Bo-Chao Chang  
Dept. of Computer Science and Information Engineering  
National Cheng Kung University  
Tainan, Taiwan  
bochao@xxxxx

Wen-Shyong Hsieh, Yu-Cheng Lin  
Dept. of Computer Science and Information Engineering  
Shu -Te university  
Kaohsiung Taiwan  
whsieh@cse.nsusu.edu.tw

Mong-Fong Horng  
Dept. of Electronic Engineering  
National University of Applied Sciences  
Kaohsiung Taiwan  
mfhorng@ieee.org

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 (IP) 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 (UM). 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 Section 3, 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-f ore 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 granularity 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;
servers or Auto-IP. The operations of UPnP devices are classified 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 content 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 event 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 according to the procedure as shown in Fig. 1. 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 \( S = \{I_i, \text{for } i = 0, 1, \ldots\} \), a sequence of image difference \( D = \{\Delta = I_i - I_{i-1}, I_i, \text{for } i = 1, \ldots\} \) is obtained by successive image subtraction. The

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

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 \( S = \{I_i, \text{for } i = 0, 1, \ldots\} \), a sequence of image difference \( D = \{\Delta = I_i - I_{i-1}, I_i, \text{for } i = 1, \ldots\} \) 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. Derive the motion estimation given as

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

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 Table 1. 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 background 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 proposed 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>
<thead>
<tr>
<th>Server Specification</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU</td>
<td>Intel® Core™2 Duo CPU E6550 @2.33GHz</td>
</tr>
<tr>
<td>Memory</td>
<td>1GB RAM</td>
</tr>
<tr>
<td>OS</td>
<td>Microsoft Windows XP Professional SP2</td>
</tr>
<tr>
<td>UPnP tools</td>
<td>Intel Tools 4UT v1788</td>
</tr>
<tr>
<td>Image Processing tools</td>
<td>Matlab 2007a</td>
</tr>
</tbody>
</table>

| WebCam                       | Logitech WebCam |

<table>
<thead>
<tr>
<th>Client Specification</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand-held Device</td>
<td>Nokia N81</td>
</tr>
<tr>
<td>CPU clock rate</td>
<td>369MHz</td>
</tr>
<tr>
<td>OS</td>
<td>Symbian S60(3rd Edition)</td>
</tr>
<tr>
<td>Developer Environment</td>
<td>J2ME MIDP 2.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Image Specification</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Resolution</td>
<td>640*480</td>
</tr>
<tr>
<td>Search region size</td>
<td>Pixel = 7</td>
</tr>
<tr>
<td>Macro block size</td>
<td>16*16</td>
</tr>
<tr>
<td>Search Algorithm</td>
<td>ESA, TSSA, HMSA</td>
</tr>
</tbody>
</table>

ACKNOWLEDGMENT
The authors would like to sincerely thank National Science Council, Taiwan, ROC for the partial finance support under the grant 97-2228-E-151-006-

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

Fig. 5 An alerting message with a key frame