

THE SENTINEL: A PROPOSED POTENTIAL INTRUDER ALERT SYSTEM BASED ON HUMAN BEHAVIOURS

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ABSTRACT. Petty crimes such as robbery and burglary are common in Malaysia, especially in urban areas and major cities. There are many reports of such cases happening right in front of the victim's premise, posing a safety concern where one can't even be safe around his/her home. Therefore, this paper proposes a Potential Intruder Alert System based on Human Behaviors (The Sentinel) utilizing image processing techniques and sophisticated machine learning to identify suspicious human behaviors. The Sentinel will then alert the users should the system detect any suspicious movements or threats lurking outside the house.

Keywords: alert, human behaviors, intelligent system, detection system, human-computer interaction

INTRODUCTION

Cases of robbery and burglary are often reported on the news nowadays and have become a major safety concern among the Malaysian public. The truth is, the crime rate in Malaysia is increasing year by year, especially in the urban areas and cities like Kuala Lumpur, Johor Bahru and Penang (Radio Australia 2013). As a result, the general public is often advised to stay alert all the time as the perpetrators of such crimes will usually search for "easy targets" such as unaware victims. Furthermore, the perpetrators are usually armed with weapons such as knives, to pose a threat to the victims, thereby causing the victims to surrender their belongings willingly while fearing for their own safety. Not only those causes property and monetary loss to the victims, but the experience of being threatened and robbed can become a traumatic experience to some of the victims.

As a matter of fact, such cases happen everywhere ranging from the noisy street to the housing area, and even in front of the house or front porch area of the victim's house. One such example is a recent real case happened in Petaling Jaya where the victim got robbed as he walked to his parked car right in front of his house (News Straits Times 2013). A more serious case happens where a top official of the Pahang Islamic Religious Department (JAIP) was shot dead in front of his house and the Pahang's Criminal Investigation Department chief, Mohd Zakaria Ahmad believed that the suspects had planned the murder beforehand by conducting surveillance on the area as the crime only took them a minute to execute and escape soon after (Today Online 2013).. This certainly raises the question of safety concern where a person would be robbed or attacked on such a short distance away from his/her home. A person should feel safe around his/her house, not the other way around.

The aim of this paper is to propose a solution to automatically identify potential intruders or threats by utilizing home surveillance camera using image processing techniques and sophisticated machine learning on suspicious human behaviors to identify potential intruders or threats before they even strike. Once the identification is confirmed by the system, it will alert the owner through cell phones as well as display a warning on the smart window display screen. This paper organize as follows; background study provides useful literature in relation to the problems and comparison of the existing systems, proposed solution introduce the Sentinel as means of solution, system design and implementation highlights the system architecture and the modules involves and finally ended with conclusion and future works.

BACKGROUND STUDY

In the market today there are various existing surveillance camera software used to monitor the surroundings of the house. Some examples were iSpy, WebcamXP, Yawcam et cetera. This software usually provides real-time monitoring as well as streaming over the Internet, allowing you to monitor your house even when you're out working. Most will even come with basic motion detection capabilities achieved by frame comparing with reference frame. The simplest one would be comparing against the previous frame where the differences in pixel on the frames will be detected as motion. However, this is not a proactive solution as it doesn't really anticipate or forecast any potential intruders or threats, effectively limiting its potential.

There is a "smarter" solution compared to the conventional surveillance camera software, such as one Intelligent CCTV developed by the UK researchers from the University of Reading which utilizes human behavior monitoring. This system is designed to be primarily used in airports and railway station to pick out any unusual movement and behaviors. Ideally, it could identify the terrorists before they strike and used to prevent incidents like the 7/7 London bombing. However, this system remains a proprietary system, meaning it is not available commercially for the public use or resale (BBC News 2010)

Nevertheless, BBC had performed an experiment to test out the capabilities of the system. The experiment involves a volunteer abandoning a bag (which is a suspicious item according to the system) among a small crowd and then walking away to see if the system can identify this behavior. The system then compares the movement among the small crowd and an alarm was issued before the volunteer can leave the area with the bag and the "possible bomber" identified. The screenshot showing the system in action is shown in Figure 1. Interestingly, it may appear to be a false positive when someone did actually drop their bag, but still, it's better than a false negative where the system didn't pick up an actual suspicious activity. It is, indeed, better safe than sorry (Today Online 2013). Table 1 shows the features of the existing systems.



Figure 1: Experiment on "Intelligent CCTV"

Table 1. Comparisons with Existing Systems

	iSpy	WebcamXP	Intelligent CCTV	The Sentinel
Monitoring + Motion Detection	Yes			
Human Body Detection and Tracking	No		Yes	
Suspicious Human Pattern Identification	No		Yes	
Proprietary (closed) System	No		Yes	No (available for personal use)

PROPOSED SOLUTION

In this paper, we propose a Potential Intruder Alert System based on Human Behaviors (The Sentinel) utilizing image processing techniques and sophisticated machine learning to identify suspicious human behaviors. The Sentinel is an intelligent system to identify human behaviors based video capture by surveillance camera installed at home. The Sentinel consists of two main modules in order to achieve those functionalities. There are Threats Forecasting module and User Alert module as shown in Figure 2.

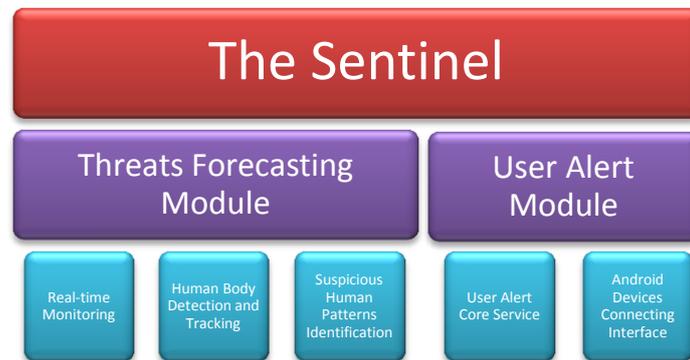


Figure 2. The Sentinel Module Diagram

SYSTEM DESIGN AND IMPLEMENTATION

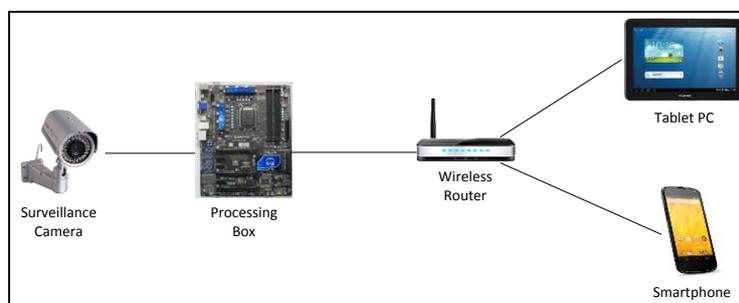


Figure 3. Systems Architecture of The Sentinel

The hardware used in The Sentinel is mapped as shown in the Figure 3. The video feed from the surveillance camera is fed into the processing box where all the image processing and machine learning algorithms are performed. The successful identification of a potential intruder or threat will then trigger the creation of a brief report which is transmitted to the users' device, Tablet PCs and smart phone through the use of a wireless router.

Thread Forecast Module

The Threats Forecasting module is responsible to identify the potential intruders before they act/attack the owner. This module consists of three sub-modules; Real-time Monitoring module to retrieve the video feed from the camera; Human Body Detection and Tracking module to detect and tracks human presence and movement apart from the surrounding elements such as vehicles, wild animals, and etc. Finally, Suspicious Human Patterns Identification module to analyze human behaviors and to determine whether it is considered suspicious or harmless. Figure 4 indicates the Real Time Monitoring where the process of background subtraction occurs when the background is removed (on the right window) from the original video feed (on the left window). The foreground or the moving objects are in white, while the static background is in the black color. For the Human Body Detection and Tracking Module, the algorithm used is known as Histogram of Oriented Gradients (HOG) with Support Vector Machine (SVM) (Dalal & Triggs 2005, Dalal et al. 2005, Tong & Chang 2001). HOG is chosen due to the fact that it provides an excellent accuracy in pedestrian detection and much lower number of false positive via its further refinement utilizing the background subtraction method (Dalal & Triggs 2005, Wang et al 2009). On the other hand, Suspicious Human Patterns are identified through parameters such durations and concealment. These parameters are evaluated together to obtain a threat probability level. When the threat probability level exceeds a certain define value or threshold, this indicates a potential threat is identified. Figure 5 shows the detection of concealment headwear such as helmets (Bounded on the head) within the detected pedestrian.



Figure 4. Background Subtraction

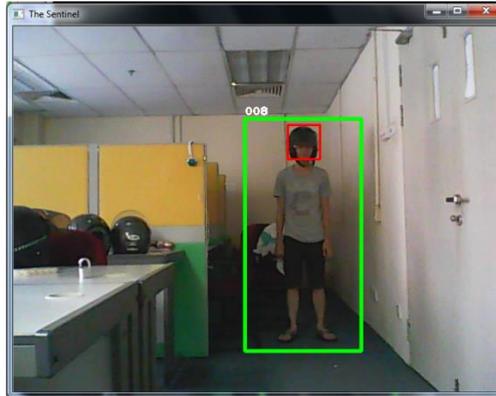


Figure 5. Detection of Concealment Headwear

For the second module, User Alert module will be responsible to alert the users once suspicious patterns are identified by the earlier module. User Alert Module consists of two sub-modules. The User Alert Core Service module is responsible to prepare a short report on the suspicious patterns and threats identified. On the other hand, Android Devices Connecting Interface module is used to connect to the users' Android devices and transmit the report as an early warning message to the user. Figure 6 shows the report consisting of a potential intruder bounded in a large box area where the threat probability score has exceeded the defined threshold (i.e. as part of the User Alert Core Service).

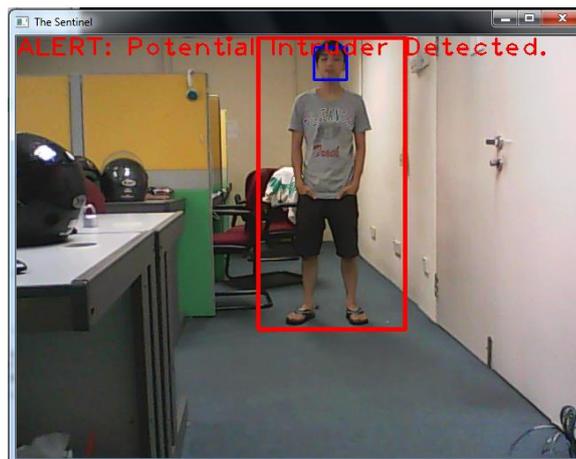


Figure 6. Detection of a Potential Intruder

CONCLUSION AND FUTURE WORK

The Sentinel is an innovative solution combining the basic surveillance abilities of a camera and the modern image processing and machine learning technique to perform identification of potential intruders. Ideally The Sentinel will be capable of combating planned robberies by alerting the users before they leave the house. As a result, The Sentinel is expected to reduce cases of robbery and burglary, leading to a safer neighborhood area where users can feel safe when going out from their home with The Sentinel keeping watch.

Currently The Sentinel is being developed and had reached the final stage of implementation. The development work on The Sentinel facing variety of challenges such as performance concerns and low detection rate due to high complexity of image processing and machine

learning tasks. Various design changes such as parallel optimization has to be integrated into The Sentinel to build an efficient and effective system.

The Sentinel has a broad set of improvements as future work such as the integration of gesture and emotion recognition to further refine the identification of human suspicious patterns. The Sentinel can also be placed on various points on a neighborhood area, monitoring and forecasting potential crimes in an entire neighborhood and reports to a central authority. Nonetheless, The Sentinel has a promising future as an intelligent system capable of providing the sense of security and peace of mind for its users.

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