

ORIGINAL RESEARCH

Design of a framework for combating human trafficking and kidnapping using smart objects and Internet-of-things

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ABSTRACT

The security problems arising from activities of terrorists, kidnappers and human traffickers in the world, at large, can be tackled using Information and Communication Technology (ICT) related approaches. This paper presents the framework of smart objects and Internet of Things (IoT) based system for achieving cost effective and time saving combat of human trafficking and kidnapping. The major components of the system are Sensor Processing Station (SPS), Media Server Station (MSS), Smart Engine Server (SES) and Digital Situation Room (DSR). The SPS is for signal sensing via a number of workstations equipped with video camera sensors, Radio Frequency Identification Card (RFID) tags to the Global Positioning System (GPS) receivers and body worn sensors while MSS will capture and store data from the sensor processing units on the cloud server. The SES will perform logical reasoning of the system such as motion detection, face recognition, position tracking and activities recognition, DSR will be used to monitor events in real-time and on-demand modes based on Internet Protocol version 6 (IPv6)-enabled communications. The work presents an integration of different technologies towards combating human trafficking and kidnapping with a view to enhance existing piecemeal development.

Key Words: Internet of Things, Embedded, Track, Smart objects, Sensors, Global Positioning System, Radio Frequency Identification Card

1. INTRODUCTION

The security challenges in the world today are multi-facet and multi-dimensional where there are terrorism, human kidnapping and trafficking. Kidnapping involves abduction and hostage taking, with the motive of obtaining ransom and it has been attributed to unemployment, poverty, religion, political issues, illiteracy, greed, corruption and so on.^[1-10] Human trafficking has assumed global trend and it is mostly committed for reasons such as compulsory and wages-free

labor, sexual slavery, home servitude, youngster begging and other forms of dehumanization. Human trafficking has been blamed on quest for wealth, political instability, militarism, generalized violence, civil unrest, armed conflicts and bad social/cultural practices.^[11-14]

Kidnapping may be used to seek pound of flesh within the political class as well as achieving religious motives by fundamentalists. For instance, in Nigeria Boko Haram, a religious extremist (terror group) kidnapped about 276 school

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girls in 2014 to force government to accede to their religious campaign.^[15] The trend of kidnapping in Europe, North America and South America has attracted the attention of the global community. Mexico suffered an estimated 105 thousands and 11 thousands of kidnapping in 2012 and 2013 respectively. Reports had showed that between 600 thousand and 800 thousand people are bought and sold across international boundaries yearly for forced labour or commercial sex. While fifty percent of the victims had been estimated to be children, seventy six percent of transactions for sex exploitation involved the underage girls who are mostly trapped using the Internet. In 2012, the total number of worldwide victims of trafficking was put at 20.9 million with about seven percent of the figure in the United States.

The advancement and complexity of the present day society has called for matching strategies for combating different forms of criminal act as well as safeguarding properties. Over the years, human personnel have been used for properties surveillance and safe keeping which has proved inefficient due to human inability to be at several places at the same time. In a bid to address this limitation, several smart technologies such as Global Position Systems (GPS), Radio Frequency Identification (RFID) and Smart Visual Systems (SVS) were developed and deployed recently for the monitoring and safe keeping of valuable items and resources in open and remote locations. Miniaturized smart systems are devices that integrate sensing, actuation and control parameters and are able to describe and analyze a situation and make decisions using adaptive or predictive data to perform smart actions. The system's provision of accurate security solutions is mostly ascribed to self-governing, closed loop, energy efficiency and networking oriented events.

The RFID technology uses radio waves to track and identify living and non-living objects. Contrary to ubiquitous bar-code technology, RFID technology requires no contact or line-of-sight for communication but operates as an automated system of wireless data capture, consisting of the tag (or transponder) and the reader. The tag is fabricated as a silicon chip that contains a unique numerical identifier that is transmitted by an attached antenna to the RFID reader through radio waves. The readers can pick up the radio waves at a range between three and thirty feet and read the stored digital information on the chip at a preset radio frequency and power source.^[16] RFID has transited several processes in the past decades as tracking and monitoring device for item delivery, courier services, luggage management, routine charge expenditure, departmental right of entry, immovable items, engineering firms and filing systems.^[17] For active RFID tags, the specification states that it should be located within some hundreds of feet from the reading device and

less than 100 feet for passive RFID tags. The task of tracking an object located outside an RFID-powered environment lies with the Global Position System (GPS) devices. GPS is a satellite-based navigation system which comprises of a network of satellites that send out signals on non-stop basis. Its technology dated back to 1973 and became fully operational in 1975 after successfully installing reliable constellation.^[18] GPS was originally meant for defining all-time operational range at any point on the earth surfaces in military defense.^[19] It is also useful for routing, scientific research, legal enforcement, navigational control and some other leisure activities.

A transponders or receivers must be attached to an object before its position can be located based on synergy between RFID and GPS systems. Since these devices do not provide see-and-act capability against non-cooperative objects (objects without transponder systems), there has been increased need for research into development of Smart Visual Systems (SVS) for surveillance. SVS is otherwise referred to as Intelligent Visual Surveillance (IVS) and focuses on the automation of object monitoring, detection, tracking, recognition, analysis and interpretation, for a better understanding of the visual content of any scene.^[20] The growth in computing technology, proliferation of storage devices with very large storage capabilities and soaring speed of the computer network have contributed to the development and deployment of the surveillance systems for effective monitoring of human and other objects activities.^[21] Video analytics, smart surveillance, intelligent video surveillance and intelligent analytics are resemblance nomenclature for the description of the concept for system-controlled signal analysis and form detection to video cameras and sensors, with the motive of systemic extraction of relevant data and information from motion picture and sensor streams.^[22]

The framework presented in this paper is an integration of different technologies towards combating human trafficking and kidnapping with a view of promoting piecewise development.

2. RELATED WORK

Latest works on Smart Objects (SO) and IoT emphasized technical aspects such as hardware platforms,^[23] software infrastructure and function scenarios.^[24] SO and IoT are applicable in supply-chain management, enterprise applications, healthcare and support for industrial bureau.^[25] Human-interface aspects of smart-object technology are just evolving and still their design principles and methodology for smart objects exceed ordinary hardware and are yet to be explored.^[26] The research is first in the exploration of smart object design space and discovery of its canonical smart-object

species.^[27] In particular, the research viewed as paramount, holistic investigation sensing, modelling and user interface issues.

An RFID and GSM technology-based child kidnap and protection system is presented.^[28] The research was motivated by the need to curtail the rising cases of missing school children due to improper and unnoticed security breaches. The research focused on the development of a system that monitors the position of a child and sends a message or alarm when he or she is out of the usual areas. The system comprised of a hand tag sensor-based location tracking system and an alarm raiser in cases of any abnormal condition such as forced removal or exit from the safe zone. The system incorporated an ARM 7 Processor LPC2148 microcontroller and Radio Frequency (RF) communication for data transmission to remote location. The tracking system is based on GPS controlled by using mode selection switches for selection of previous or new locations. The limitation of the system is its inability to identify kidnappers.

The authors presented a video surveillance and monitoring system (VSAM).^[29] The research was motivated by the need for the automatic monitoring of a large area using video analytic systems. The research objective was to develop a smart sensor-based single user monitoring system for large geographical area with capability for processing information before transmission to the control centre.

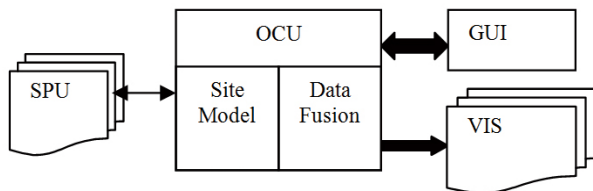


Figure 1. VSAM Architecture

The schematic diagram of the system architecture is presented in Figure 1. It has a Sensor Processing Units (SPU) which offers an intelligent filter across the camera and the VSAM network and also performs video imagery analysis and discovery of significant entities or events and symbolic transmission to the Operator Control Unit (OCU). The OCU receives the output from the video processor for each SPU and merges the information, site model and a database of known objects to infer user-centered activities. It also has a Graphic User Interface (GUI) through which the operator can test individual sensor units, as well as the entire test bed sensor suite via the GUI. Finally, there are visualization nodes that are needed for 3D display of events in the surveillance area and also for promoting data fusion. The work can be regarded as one of the leading works in surveillance systems.

The research provided a framework for automatic large area monitoring using videos. The system allows cooperation and synergy among multiple sensors with satisfactory consumption of bandwidth. This feat is due to the fact that only symbolic information is delivered through the network. The sensor relies on arbitrary human command; hence the system is semi-autonomous.^[30]

A wireless sensor network-based system that can track and monitor materials in construction sites is developed.^[31] The research was motivated by the need to envision the likely events of utilizing ZigBee as a protocol in a wireless sensor networks based on ZigBee for material tracking. The system was designed based on ZigBee networks on RF and ultrasound platforms for improved positioning accuracy and cost benefit. ZigBee routers were placed at the entire lay down yard within the trigger ranges for the detection of the events that are related to the movement of smart tags in different places. Data collected from every router is conveyed to the base station, which joins with the ad hoc path in the network topology to act as the field office. Identification and categorization of various smart tags were carried out and the construction materials were tagged based on material property and measurement type within the geometry of the site. The system is suitable for equipment and material tracking, however, the cost implication could be high and cannot function in see-and-avoid environment due to its reliance on tags.

The authors^[32] present a fuzzy-based indoor tracking system for localizing object in an environment characterized by Wireless Sensor Network (WSN). WSN sensor node detects if there is any target node and receives a response. Upon the receipt of the reply, the sensor node calculates the times for receiving signal and the return trip to the target as well as the strength of the signal received. Fuzzy logic model was applied for obtaining the x-y coordinates of the different nodes. The major limitation of the system is its failure to explicitly define the identity of the object.

A kidnapping alert and location identifier (CKALID) system is presented.^[33] A microcontroller incorporating a trigger activated GSM/GPS module was programmed to report via the GSM communication network (using SMS messaging) to a monitoring center. The first component is the tracking device which is attached to the belt of an individual being monitored. It comprises of a GPS module, a microcontroller and a GSM module. The second component is a receiver device which receives the GPRMC messages and sends it to the monitoring workstation PC via the Internet and running Google Earth software and Franson GpsGate Client software (FGCS). FGCS is a web-based GPS tracking software with

real time view, advanced system alerts and reporting. Some of its functions include using JavaScript to gather GPS position; normalizing the GPS connection; GPS simulation and logging; sharing one GPS to several applications using virtual communication ports; connecting a GPS to Google Earth; sending GPS data over HTTP to a personal server; multiplexing and splitting NMEA streams. When a person is kidnapped, he/she presses the trigger on his/her belt to trigger a continuous monitoring of his/her position by the system. This device promotes fast response and quick rescue of kidnapped victims. The full implementation of this system however requires the integration of advanced technologies for multimode tracking.

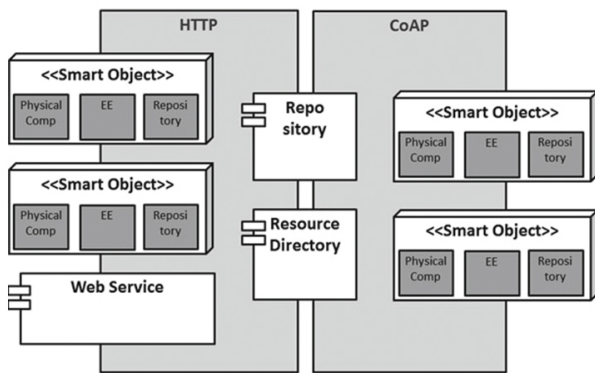


Figure 2. Architecture of Smart Objects

The authors^[34] proposed a mobile agent for global intelligence interaction and middle-ware solution-free platform for the integration of autonomous objects, agents and open standards for communication and cooperation. The integration is based on the architecture presented in Figure 2. The Resource Directory (RD) is the name server and holds the resource images as a component of the information layer. The smart objects can use the presented API to search the RD for uncovered resources in the system. The RD may be a component of the P2P overlay over the IoT system. Queries are based on URL, resource name, output specie, semantic explanation and practical material location. Generic Web service is utilized in abstraction of heterogeneous hardware, software and smart objects resources coordination of application and task implementation. The coordination provides application oriented aptitude, divulges exterior services into the system, proves gateway or stand-in for incongruent networks enabling interoperability and facilitates human-machine interactions over the Internet. A store room is required for the storage and exposition of the universal and application-oriented assets (such as mediator task codes and compositions that are accessible via the RD lookups) into the system. The system provides communication interfaces

for HTTP and CoAP protocols for right of entry over different networks. The integrated system is suitable for use in application-specific IoT system design, smart object or mobile agent-based active service and system service response latency estimations. Additional system and network-specific parameters are however required for real-world evaluations coupled with the omission of some unavoidable security and seclusion issues in agent-based methods.

An IoT-based architecture of web and smart home interface using GSM is proposed.^[35] The IoT-based architecture presented in Figure 3 comprises of implanted system, sensors and actuators which are the corporal mechanisms which interact straight with users. ICT, everywhere or invasive computing and Internet protocols offer communication between devices and administer prolific user communications. The three functional units of the architecture are Internet, things and semantic-oriented. Internet Oriented implies Internet and its connected technologies and it plays a middleware between the user and intelligent parts. It is responsible for the formation of a vibrant plan of the factual/substantial globe within the digital/practical space. Things Oriented is otherwise called Intelligent Things (ITs) and connotes sensors and actuators which relate with the environment in a consistent manner. Semantic Oriented implies Intelligent Process (IP) and presents the knowledge and decision making processes.

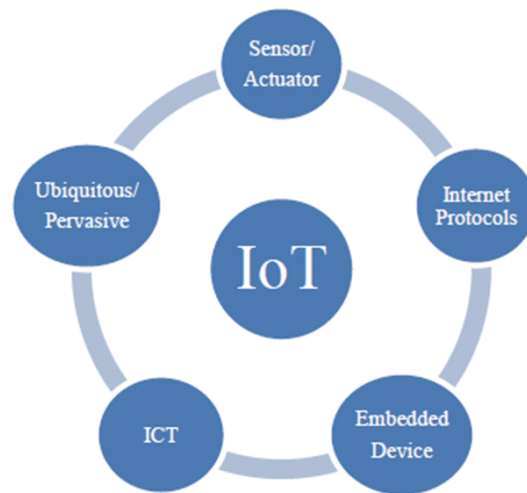


Figure 3. IoT Architecture

The architecture enables users to control and keep an eye on smart devices via GSM and Internet supports. There is room for users to give commands which are converted into GSM-SMS commands before sending to embedded system module which directly connects with the devices via GSM. Lastly, the client commands are filtered for implementation by microcontroller which controls and acknowledges any

electronic objects in-torch. It is reported that preliminary test prove that the architecture is suitable for monitoring and control of devices in the deployed environment with numerous opportunities in areas of quick release, zero data misplace, low charge, suppleness, easiness and energy economy. It however requires established and strong GSM network for optimal performance. It also failed to give consideration to video streaming of home activities using GSM-MMS and RTMP protocol which are very vital for improved security.

3. PROPOSED FRAMEWORK

The proposed framework has two phases, namely: hardware operational requirements phase and software analytic framework phase.

3.1 Hardware operational requirements phase

The hardware operational environment of the integrated sensor framework has four stations of activities, namely: Sensor Processing Station (SPS), Media Server Station (MSS), Smart Engine Server (SES) and Security Management Station (SMS). The conceptual block structure of the framework is presented in Figure 4.

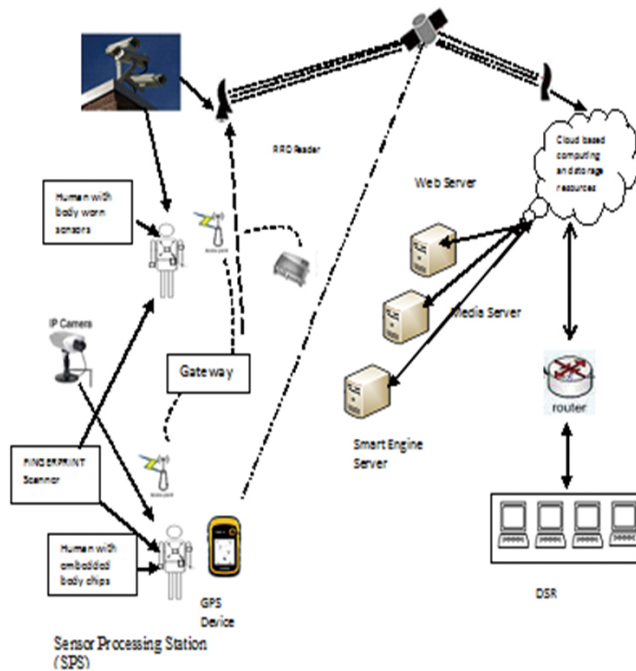


Figure 4. Block structure of the Framework

The SPS has hardware and software for signal sensing. SPS comprises of workstations equipped with video camera sensors, RFID tags, GPS receivers and body worn sensors.

Video camera sensors are required for capturing the video data of the area being monitored. A nano-digital camera will

also be embedded into a Broach-type model attached/hidden to/in buttons or human hair for taking and forwarding real-time pictures to the DSR. RFID tags are required for monitoring objects' location in indoor environment while GPS provides global monitoring. The SPS requires ID cards carrying chips as embedded tools for effective checkpoint identification of carriers. These chips could be embedded or "injected beneath the skin" or placed into wristbands, button or hair of an individual for monitoring and safety.

The captured data from the sensor processing unit are stored on the cloud-based MSS. The fact that the amount of data generated from the system is enormous informed the choice of a cloud server for housing the data.

The SES is responsible for logical reasoning of the system. It handles motion detection, face recognition, position tracking and activities recognition. It saves the outcome on the server for onward transmission to end-user devices and it is located in the cloud.

The Digital Situation Room (DSR) is designed to monitor events in real-time and on-demand modes based on the RFID tags and the embedded chips. The station is also responsible for querying the activity database.

The Internet Communication Protocol is a compulsory requirement for connectivity. Internet Protocol version 6 (IPv6) is selected as the communication protocol and for provision of addressing scheme for data transfer on the web. The preference of IPv6 for the research is due to its strong support for highly scalable address scheme, Network Address Translation (NAT), Multi-Stakeholder (MS), multi-cast and any-cast mobility, increased hardware, automatic configuration and address scope. It also support use of identifiers and improved functionality, extensible Internet to the web of things, auto-configuration and use of fully Internet compliant gateways.

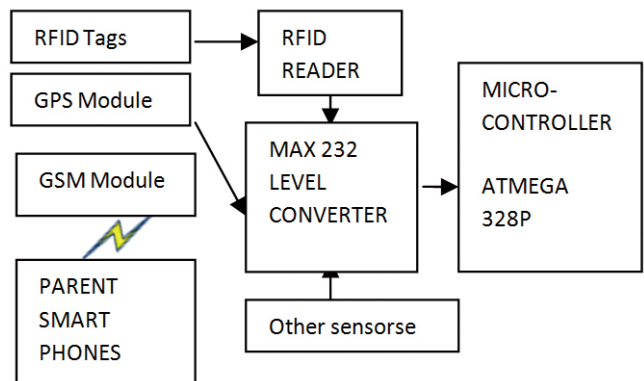


Figure 5. NVM Sensor Hardware System

Non-Visual Module (NVM)

The hardware Components of the NVM is depicted in Figure 5.

The NVM comprises of IOT objects and RFID sensors and Geographical Positioning systems that are responsible for signals and locatio.n

a. Video Capture station

The video capture station is equipped with digital cameras and software that are to be used for sensing, digitizing, and compressing video signals. It comprises of workstations equipped with video cameras. The concept of the visual monitoring sub-system shown in Figure 6 is to make use of the Internet as the communication medium. Video data captured in the monitored area is sent to a video capture adapter board attached to the system. On the video capture adapter card, an analogue to digital converter (ADC) chip converts the wavering analog video and audio signals to a pattern of 0s and 1s, which is the binary language computer understands.

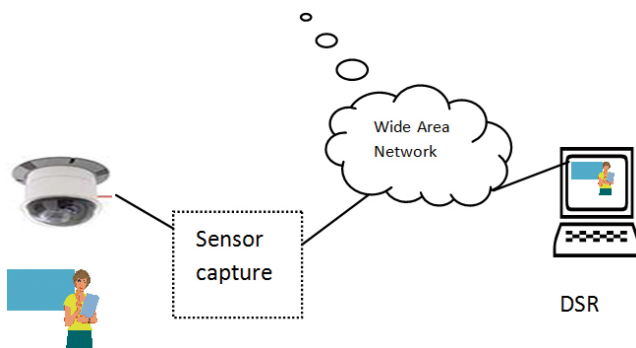


Figure 6. VM sensor Hardware system

b. Communication Medium

The Internet will be used as the communication framework for real time video transmission to remote locations.

c. The DSR

The DSR stations will be used to view the raw video files either live or on demand after they have been stored on the server. They decompress video streams and display the video on the video display unit. Each video playback station will have playback client software based on Microsoft media player.

3.2 Software analytic framework phase

The proposed system consists of different modules for object location detection and tracking using RFID analyzer as well as face and activity recognitions.

a. Video Analyzer

The system cameras will capture images of the scene and will record it in a video storage device or passed to the next modules for analysis. Identity recognition and intrusion detection will then be carried out using video analysis module. After a kidnapping scenario is detected by the system, object (human) detection, classification and tracking operations will follow, features will then be extracted from the face and the whole body. The extracted facial features will be passed to the face recognition module while the features from the whole body will be passed to the activity recognition module. The extracted set of features will also be used to identify intruders. The activity recognition module is responsible for action segmentation and recognition. These modules generate different alerts which are stored in the database for subsequent retrieval or viewing. It is noted that face and activity analysis modules can be executed in parallel. Figure 7 shows the logic of the operation of the analytic framework.

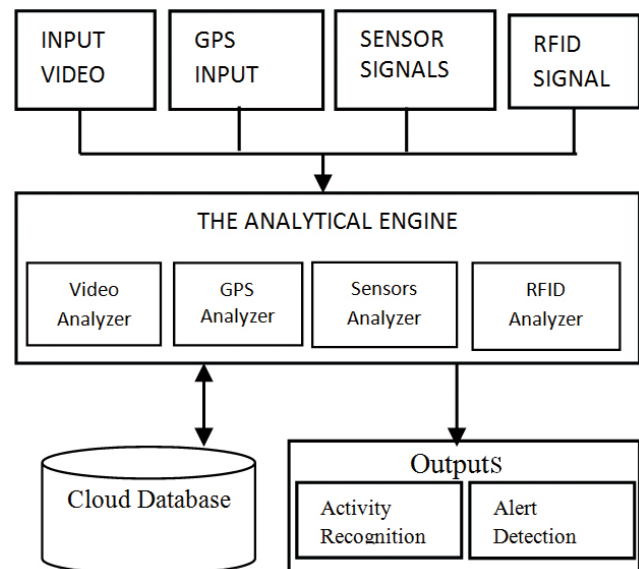


Figure 7. Software Analytic Engine of Proposed System

b. GPS Analyzer

The GPS is for global location and tracking. For outdoor surveillance, humans will be equipped with GPS receivers and the location of the user will be tracked continuously. Obtained information will be sent to the DSR and in case the location is outrageous, an alert will be generated as acknowledgement to the remote user for onward transmission to the law enforcement agents for necessary action. In case of removal of the devices from the user, an instantaneous alert will also be sent.

c. RFID Analyzer

The RFID will be used for indoor localization. For indoor surveillance, humans will be equipped with wireless wearable sensors and RFID tags. While indoor and with the help of wireless sensor networks, the location of the user in the environment will be tracked continuously. This information will be sent through GSM to remote stations that are monitoring the objects. If the allowed radius of movement is exceeded, an alert will be generated and sent to the remote user while a short video stream of the previous durations will be sent to the remote user for transmission to the law enforcement agents for necessary action.

d. Sensor Analyzer

This will be used to analyze and connect other sensors such as infrared sensors, motion sensors, ultrasonic sensors, laser sensors and buzzer to the tracking system.

4. CONCLUSION

This paper has presented the integration of smart technologies and Internet of Things to track criminals and promote safety of lives and properties. Focus has been on the design of hardware and software requirements in some details. Future research shall address the implementation of the proposed framework as well as its evaluation for effective combat strategy of human kidnapers and traffickers.

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