E-Eye: A Multi Media based Unauthorized Object Identification and Tracking System

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***Abstract*— As a global concern, the public safety, which has been going on since the day that humankind came into being, is a serious issue and needs to have closed attention. Traditional understanding of security relies on the general principles of manual process and behavior in which specially trained forces are essential actors. It is a labor intensive and time consuming process with very limited outcome. Therefore, with the help of technology the necessary support in terms of monitoring can easily be provided. Especially remote surveillance complemented with Radio Frequency (RF) is capable of providing to the point information regardless of the distance. An experimental study has been conducted on this very issue to show the reliability, timeliness, and cost of this high quality service. The system, called E-Eye (A Multimedia Object Identification and Tracking System), introduced in this study will demonstrate the underlying architecture via web, client and mobile applications to its' users in order to view the real time images gathered from the monitored area and selected objects for further tracking by utilizing the historical data (i.e., captured images of every cameras, GPS and RFID data) of the object.**

Keywords*— *Object tracking, RFID, GPS, Image Processing, Multimedia Analysis, Object Detection, Keypoint Matching, Video Processing, Object Capturing

I. Introduction

Public safety is, and has been a primary concern for human beings since the beginning of civilization; it is because of this that serious attention should be paid to improving it. An absolute reality is that governments from different countries are currently to solving safety issues. Arnold Schwarzenegger, the ex-governor of California emphasized the importance of public security by saying *"Government's first duty and highest obligation is public safety"* [13]. However, it is not an easy task since security requires many parameters that are predictable, and unpredictable and can directly affect the management of the systems because of the complexity of the solution. Thus, it is not possible to give a complete solution that adequately provides public safety with our current level of technologies. Contemporary, general principles and behaviors of implementing security focuses on measures which rely on the security forces to dissuade safety threats and minimize their impact on the citizens.

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II. Importance of Problem

Some technology based radical measures are necessary on a nationally and international level. One of these radical measures is object tracking [1].

According to the report from the U.S. department of education [2] published at the end of December 2009, there were 3,581 illegal weapons carried on campuses, 7,287 motor vehicle thefts and 741 arsons reported. As a result total 11,609 incidents were identified on campuses all over the Unites States during the same year.

According to the international Statistics on Crime and Justice Report of the United Nations Office on Drugs and Crime (UNODC) [3], motor vehicle crimes involving vehicular theft reached between 300 and 350 worldwide. Reports also indicate that for every 100,000 people, the number of crimes involving kidnapping and assault was between 800 and 850.

As can be seen from the statistics, there is a need for a system that can identify, focus, track and position security systems to prevent crimes that occur worldwide which result in the loss of billions of dollars and the disruption of community peace.

The systems that identify, focus, track, and position security systems have been used in many different areas independently or in varying combinations. Compilation of these technologies into a hybrid system can enhance the quality of life via timely, reliable, cost effective responses in different areas of public safety. Some of these areas are vehicle theft, kidnappings, military operations, etc. Therefore, within the scope of this research we are proposing a system called E-Eye: A Multi Media based Unauthorized Object Identification and Tracking to identify the activities of the objects through the use of readers, tags, and multimedia (such as video cameras, global positioning systems) through the use of a Central Interpreter System (CIS). The goal of this study is to identify the unauthorized object in order to focus on it by utilizing the camera surveillance until the moment of danger. Thereafter, coordinates of the object are determined by a GPS module to enable the officials to locate the danger. Last but not least all these processes are managed by the Central Interpreter System according to the collected information in real-time by the component devices.

III. System Details

A. Overview

The E-Eye system is composed of five modules. These modules include the Central Interpreter System (which is the main module used to manage the system), a camera surveillance, an RFID, a GPS, and a notification module. Additionally, the system will be web-based in order to integrate all modules within a specific network. Figure 1 shows the modules of the system.

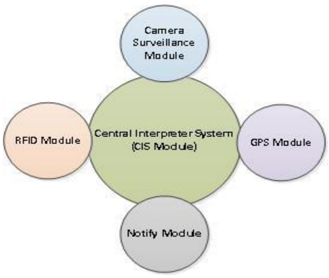

Fig. 1. The Modules of E-Eye

General interactions of the module are shown in Figure 2. First, it aims to identify, follow, match objects and get their location in real-time. The system needs to read the object's RFID tag numbers while the object comes into any camera's view angle. Then, the system tries to match a RFID tag number with the object identified. If the system matches a RFID tag number with the object between locations, the system saves the date, the time, and the position of the object and starts tracking the object between locations. At the last step, the system will calculate and show the object path to the officials; however, if the system cannot detect or match the RFID tag number with object, the system will again save the date, time, and a position, and then warn the end user.

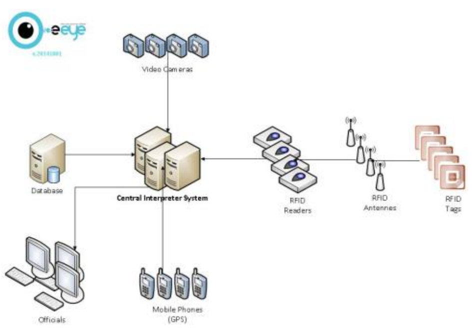

Fig. 2. The Overall Structure of E-Eye

B. Overview

There are different actions for each roles and modules of the E-Eye system. Each of them has different responsibilities. The roles begin with officials. Officials are the group of person who are capable of logging onto the web page of the E-Eye (known as the E-Eye web). Additionally, they can enable a function to list objects captured by the system and browse its details through the web system. The E-Eye web provides opportunity for filtering search.

Furthermore, the RFID module can read tag information from the object. It can also push tag and some other local information to the central system of the E-Eye system. Besides that, the RFID gets a response from the central system and achieves its action.

The camera surveillance module can capture the image of the object and track the object through the streaming of the video. After that it can push each image of the object and some other local information to the central system.

Moreover, a mobile device behaves as a GPS module bundled with an RFID tag. It is able to push real time coordinates of the object and some other local information to the system.

Last but not least, the Central Interpreter System (CIS) is very important for the whole system itself to orchestrate its' functions properly over a centralized point. It reads all gathered data from a database of the E-Eye. The CIS also analyzes information from the database according to their sensed time as well as matches the information according to the information. Likewise, it identifies the object path to illustrate it on an environment map.

All actions of the system are summarized and specified in Figure 3.

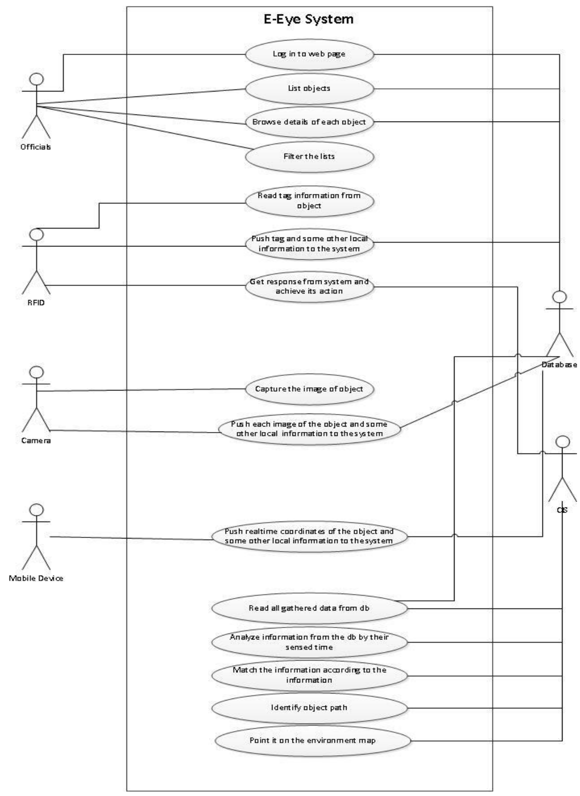

Fig. 3. Use Case of the E-Eye System

C. Overview

A database design is presented in Figure 4. The design contains the tables, its fields with types, and their relationships in tables.

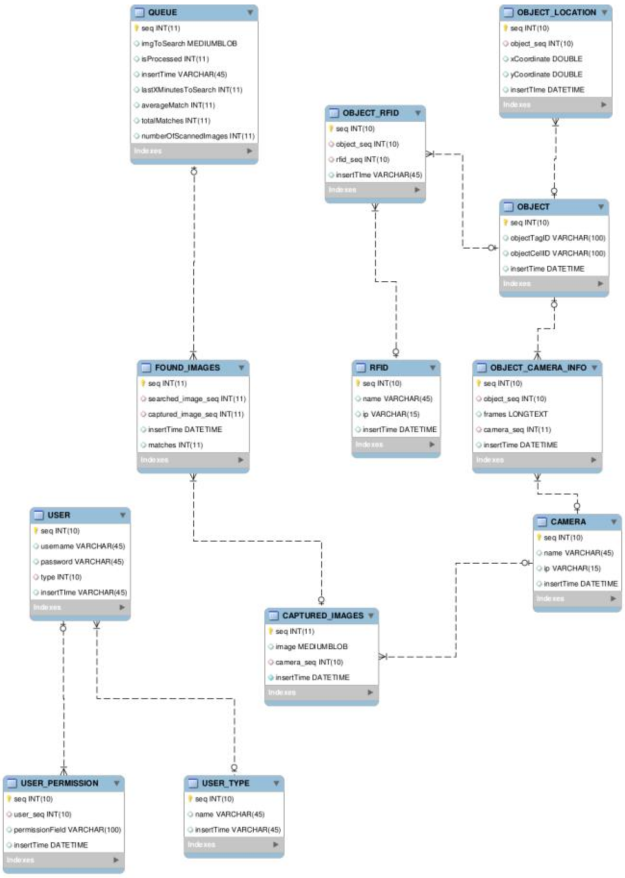

Fig. 4. Database Diagram of the E-Eye System

IV. Software Development Process

The web page of E-Eye System for officials, a batch side, a mobile Android application for GPS and a RFID integration are coded by using Java technologies. The web page and the batch side are deployed to the Apache Tomcat server. Additionally, MySQL is selected as the database in order to store data of the system. One of the important thing about the database is that it's reliable enough to support the system through this project.

A. Components

The E-Eye system is divided into seven components. These components are the E-Eye-batch-interpreter, an E-Eye-client, an E-Eye-core, an E-Eye-web, an E-Eye-web service, an E-Eye-mobile and an E-Eye-RFID respectively. Therefore, all the components are presented in details in order to exhibit their aims accurately. It is clear that the E-Eye system with its components is now ready to launch through Google Play and from the UALR host.

B. Foundations

First of all, the E-Eye-core contains basic functions, entities, and enums to be used by other components since it is a library. The E-Eye-web service is a web service component which acts as a bridge among other components of the E-Eye system. All other components call the E-Eye-web service in order to achieve data flows. The E-Eye-web service contains all business functions to prevent same or similar type of duplication and distributions to all business functions of other components.

After the role of the core component is clarified, the E-Eye system can be defined with its components. Additionally, the E-Eye-client is a graphical user interface tool for the users to observe the streaming of each camera. Additionally, it also provides several functions. One of them is capturing an object by drawing a frame with a mouse. Afterwards, other functions are performed post-capturing. At that level, a user stores a captured image along with the associated time to conduct a backward search to that image within all of the cameras' captured images (within a specific time domain).

Furthermore, the E-Eye-web service is a web application. The E-Eye web application runs on all major web browsers, including Apple Safari, Google Chrome, Microsoft Internet Explorer, and Mozilla Firefox. It displays a page of results for captured images to show found images and its cameras' information matching with the captured images to the user.

The E-Eye-RFID is a batch application which all signals from different readers within all environment based on tags of the object. All gathered data is sent to the central database to accomplish further events.

Moreover, the E-Eye-mobile is an Android-based mobile application. It behaves like a GPS module in the object. There are several input controls in a page of the mobile application. The most important role of the mobile application is to send a GPS location of the object in a specific timeframe constantly.

Last is the E-Eye-batch-interpreter component. It is the central interpreting system that runs all basic automated functions in a batch mode. Detecting a motion in a camera view, storing a captured image in a detection motion, and finding searched objects in all captured images in detected motion, and processing RFID tags are some of functions included in the system.

C. User Interaction with E-Eye

A main screen of the E-Eye-client GUI tool is presented in Figure 5 and Figure 6.

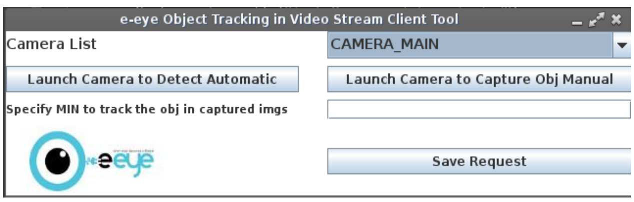

Fig. 5. Graphical user interface of the E-eye client

The screen provides several controls. One of them is "Camera List" which helps the user change a camera due to control. All cameras connected to that system fill the list box automatically. Additionally, there are two buttons to start the streaming of the selected camera.

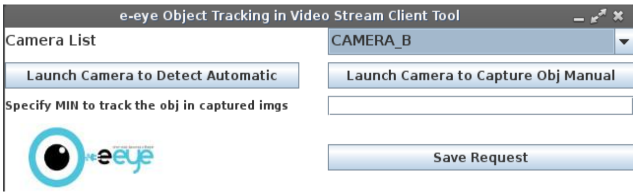

Fig. 6. Graphical user interface of the E-eye client

The Launch Camera to Detect Automatic button opens a new screen that detects all other properties automatically. Besides that, the Launch Camera to Capture Obj Manual button opens a new screen that helps the user to capture an object from streaming. There is also an input control called Specify MIN to track the obj in captured imgs. This feature gives a user's minute-input to store a captured image by using the Save Request button.

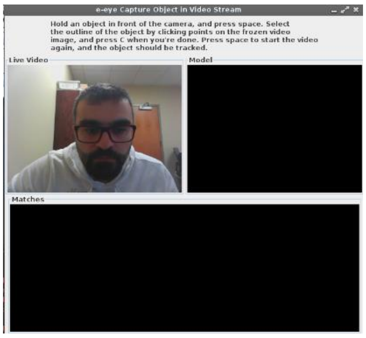

Fig. 7. Screen of the Capture Object in Video Stream manually

Here is an illustration for how a user can use the screen in order to capture an object. The Live Video frame is a frame for displaying live stream from a selected camera. Model Video frame is separated to display a captured image statically [8]. On the other hand, Matches frame is on the screen in order to display intersection points and lines between Live Video and Model Video frame (see Figure 7).

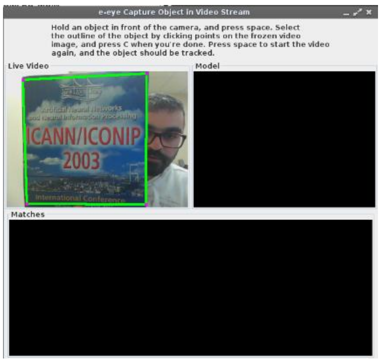

Fig. 8. Captured object by drawing frame in Live Video frame

After capturing the book object (see Figure 8), it is displayed in the Model Video frame (see Figure 9). This means that "the book object is selected to search in live video". A result is showed in the Matches frame with intersection points and lines in real-time.

Fig. 9. Graphical user interface of the E-eye client

Figure 9 also shows that the book object is not found except in live video. That is why there is no intersection points or lines in the Matches frame.

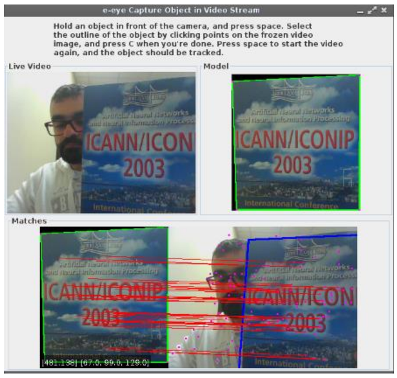

Fig. 10. Book object is found with the same direction as original object in Matches frame

However, Figure 10 shows that the book object is found within a same direction as an original object in the Matches frame. That is why the result is shown with intersection points and lines in the Matches frame.

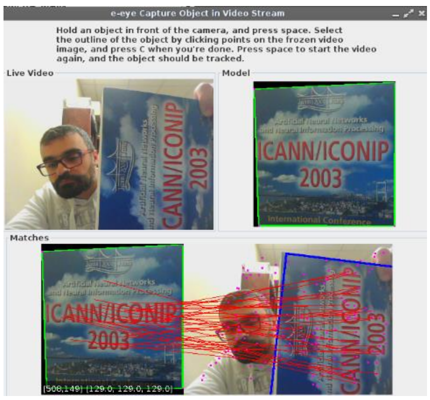

Fig. 11. Book object is found with the cross direction as original object in Matches frame

Figure 11 shows that the book is in cross direction however it can still be found with that direction as an original object in Matches frame. That is why the result is shown with intersection points and lines in the Matches frame.

Fig. 12. Book object is found with the different direction as original object in Matches frame

Figure 12 shows that the book is in a different direction, however it can still be found with that direction as an original object in Matches frame. That is why the result is shown in the Matches frame with intersection points and lines in real-time.

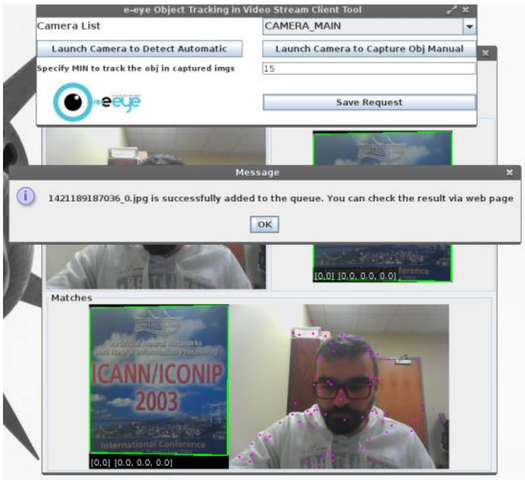

Fig. 13. Selected webcam as a source and activated Facial Keypoint Detection for live stream

After selecting the book (see Figure 13), it is sent to the central interpreting system in order to search it within images in last fifteen minutes from all cameras connected to the system. From now on, finding a searched object in all captured images in detected motion will be achieved by the central interpreting system called the E-Eye-batch-interpreter.

Web Services

Endpoint	Information
Service Name: {http://ws.webservice.eeye.ualr.jac.com/}AdminWS Port Name: {http://ws.webservice.eeye.ualr.jac.com/}AdminWSPort	Address: http://localhost:8080/eeye-ws/AdminWS WSDL: http://localhost:8080/eeye-ws/AdminWS?wsdl Implementation class: com.jac.ualr.eeye.webservice.ws.AdminWS
Service Name: {http://ws.webservice.eeye.ualr.com}GenericWS Port Name: {http://ws.webservice.eeye.ualr.com}GenericWSPort	Address: http://localhost:8080/eeye-ws/GenericWS WSDL: http://localhost:8080/eeye-ws/GenericWS?wsdl Implementation class: com.jac.ualr.eeye.webservice.ws.GenericWS

Fig. 14. Web services of E-Eye

The E-Eye-webservice, as shown in Figure 14, provides two web services. One of them called AdminWS is built for the Administration side. The other one called GenericWS is built for any other usage. Components of the E-Eye system achieve business functions by using the AdminWS and the GenericWS with its ports.

Fig. 15. Web methods of GenericWS web service

Some of web methods of the GenericWS are showed in Figure 15. A file is called a WSDL, Webservice Definition Language. It is used to define all request and response entities of the functions for the client components.

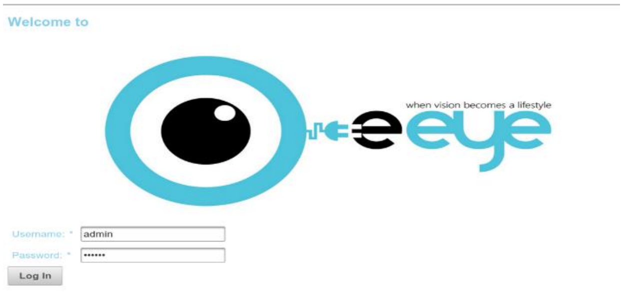

Fig. 16. Web application of E-Eye called E-Eye-web

A login screen of the E-Eye-web is shown in Figure 16. It implements a displayed page for captured images to demonstrate found images and its cameras information matching with captured images.

Fig. 17. Web application of E-Eye called E-Eye-web

The E-Eye-mobile is an Android based mobile application. It behaves like a GPS module in the object. There are several input controls in a page of the mobile application. An URL is a field to keep a server address of the web service to call a function. Additionally a Tag ID and a Mobile Device ID are fields to bind a mobile device and an object with the RFID. This combined data is used to send the object position. So, the most important role of the mobile application is to send the GPS location of the object constantly in a specified period of time.

V. Conclusion

When E-Eye is implemented with all of its sub-modules (to achieve identification, focusing, tracking, and positioning of an object). It can enhance the quality of life. From a software engineering perspective, it is scalable, reliable, and cost effective.

Most of the objectives identified in this project were achieved. In the future, the E-Eye has the potential to scale-up. There are still goals that were proposed that have yet to be achieved. The capacity to scale the E-Eye web and the E-Eye client into an all-inclusive graphical user interface with full functionalities can be achieved. Whatever future work is done, it will take a great deal of thought and planning, but the groundwork is already laid. The E-Eye has the potential to become truly powerful.

VI. Future Work

Nice to have improvements of the E-Eye project that the E-Eye has currently two modules to achieve an image and a video processing for its clients. These modules are the E-eye-client and the E-eye-web respectively. The E-eye-client focuses on tracking an object in video streaming from live displays of cameras placed properly. On the other hand the E-eye-web is dedicated to display results with images including camera information of a searched object within all captured images. Two modules may be merged into a single graphical user interface. Additionally, a map module may be implemented to the GUI in order to display the object location on the map.

The E-Eye project should implement the following tasks in order to enhance its solution capacity. Firstly, whenever a user clicks an object in the live stream video, the E-Eye should automatically recognize a requested object by finding initial edges of the clicked object in order to search the object within all captured images. Afterwards RFID signals can be jammed with RFID jammers. Therefore, the E-Eye should eliminate that a weak but vital point. RFID signals can be read by any other antenna. Additionally, they can be duplicated. Thus, the E-Eye should eliminate this issue to shield its RFID tags. Besides, if tags there need to be used, a tag can identity its purpose. NFC technology may be used instead of active or passive tags. The important point is that the NFC needs a low distance to interact with its reader. Last but not least currently, the E-Eye system uses a mobile phone to illustrate an object in which carries its own the GPS module to gets its GPS location. In the future, there will be a built-in GPS module.

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