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VEHICLE MONITORING SYSTEM USING MOTION DETECTION AND CHARACTER RECOGNITION ALGORITHMS FOR USM CAMPUS

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Abstract. *Maintaining security in university campuses is most definitely the talk of today. Problems surface when security personnel need to constantly patrol the campus grounds to monitor activities of vehicles. With the possible introduction of the motion detection and character recognition algorithms in security systems of the future, vehicle identities such as license plate numbers can be captured and processed at the security post to make it possible for the vehicles to be monitored remotely. This will minimize the job of the security officers in patrolling the campus grounds. The methodology of how the motion detection and character recognition algorithms work will be presented in much further detail in this paper. Issues regarding both of the two algorithms will also be brought up. Finally, the implementation of the results will be presented.*
***Keyword(s)**: Motion detection algorithm, character recognition algorithm, image processing*

1 Introduction

The Vehicle Monitoring System (VMS) is designed primarily to monitor vehicles within the campus grounds from the moment they enter the gates until they leave the compound. Once vehicles enter into the campus grounds, they are also monitored when they enter and leave the major parking areas around the campus.

This system is targeted for the security personnel, enabling them to monitor vehicle activities within the campus with much more ease compared to the conventional method of patrolling the grounds in motorcycles. VMS ends all debate about possible high-tech campus security and surveillance system by incorporating motion detection and image processing technologies.

These technologies form the core of VMS and play an integral part in both performance and efficiency. The built-in motion detection feature in the security cameras, strategically located at the security posts and car park entrances and exits allows the system to detect vehicle motions as soon as it approaches the entrance and automatically triggers the security cameras to capture the image of the vehicle license plate, whereby it identifies each vehicle by its license plate number.

VMS aims to be the forerunner in campus surveillance of tomorrow, just by being unique in its own ways. The system allows security personnel to generate daily logs on vehicles entering and leaving the campus grounds by monitoring the time they enter and the time they leave. This is just one of many features that are available for users of this system. Another unique feature of VMS comes in the form of a search engine. Not only does this engine allows users to search for vehicles located anywhere around the campus, it is also bundled together with an interactive 3-D map of the campus. By the click of the mouse, VMS takes users into every zone within the campus and provides users with an option to search for vehicles that are located in car parks around the campus. VMS is nothing without its two core features: the Motion Detection and Image Processing Technologies.

2 Motivation

Security is fast becoming an issue, not only in university campuses but also in other areas. People always moan about security personnel not doing their job the way they are expected to. Sometimes, we just have to give them a break and put ourselves into their shoes. Imagine them having to patrol the entire campus in motorcycles. By the time the security personnel reach the location, the culprit might have left. We obviously do not want this kind of thing to happen in Universiti Sains Malaysia (USM). Bottom line is, VMS is here to help save the security officers' time and energy of having to go about the campus in motorcycles in other to ensure everything is in order.

This is where the motion detection and image processing modules play their roles as the beating heart of this system. Putting aside the other two modules in VMS, we are just going to discuss the algorithms for both the motion detection and image processing modules at this point in time.

Our objective is to design an efficient algorithm for both the motion detection and image processing modules in order to obtain effective results.

3 System Description and Function

VMS basically works by capturing the image of the front portion of an on-coming vehicle, specifically the area where the vehicle's license plate is, takes that image and processes it to determine if any character is present in that image. In this case only the registration number is detected. The characters detected will then be processed into readable and text-based characters to be used for data comparison.

The main advantages and functions of this system prototype are:

- It works continuously for 24 hours, unlike the current system which only operates at night.
- It uses vehicle registration number for identity verification thus eliminating the problem of unregistered vehicle owners misusing student's matric card to enter the university compound illegally.
- It stores the vehicle registration number of unregistered or unauthorized visitors for security purposes.
- It generates daily log files or reports for monitoring vehicle activities of registered and unregistered vehicles.
- It locates a vehicle and displays it in an interactive map for security checks.
- Uses motion capture to trigger automatic image capture.

The complete system prototype will be broken down into 4 specific modules shown in the diagram below:

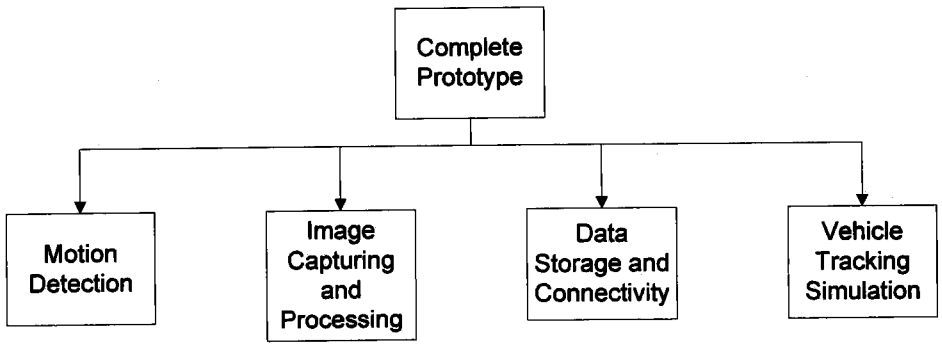

Figure 1. Four modules of the complete system prototype

3.1 Motion Detection Module

The image capturing module will include developing functions to automate image capture and to synchronize the image capture function with motion detection. Once the camera detects any motion from on-coming cars, the camera, which will be placed strategically, will be triggered to capture the image of the front portion of the vehicle, specifically the area where the vehicle's registration number plate is.[1]

3.2 Image Capturing and Processing Module

The image captured from the first module will be processed and the data obtained will be used as a means of identity verification. This module will include image filtering and image processing to detect the characters on the vehicle's registration number plate and changing the characters into readable text-based characters.

4 Development Methodology

The development methodology that will be used in the development process is the Object-Oriented Design methodology. This methodology is suitable because it is based on the concept of "designing logical solutions for a given problem".

The sticker and the matric card systems pose a similar but serious problem that is both systems fail to monitor and control the activities of vehicles that enter the university compound. Thus, the most logical solution would be to use another means of verification and in this case the proposed solution would be to use the vehicle's license plate number as the "solution object" simply because it is unique to each car and that it is not easily duplicated, unlike the sticker system.

The other objects that are involved in this system prototype are the modules that make up the entire system which are the image capturing module, the image processing module, the data storage and connectivity module and the vehicle tracking simulation module. These modules or "objects" will be integrated to form the whole of VMS prototype.

5 Implementation

This section on implementation discusses the features of VMS as well as how this system actually performs its daily duties as a security and surveillance system. All in all, VMS needs 3 major stages to complete its primary function which is to capture vehicle information and store it in its database.

5.1 Detecting Vehicle Motion

VMS detects vehicle motion via a high-tech motion detector built into the surveillance cameras. The moment a vehicle nears any one of the USM gates, the built-in motion detector will detect any motion by the approaching vehicle. From the camera interface of the system, the security officers will be able to see blue line patterns within the camera viewing window which indicates that there is motion being detected.

5.2 Capturing and Processing of Image

Once the vehicle motion has been detected by the motion detector, it will automatically trigger the surveillance camera to capture the image of the vehicle. This image will then go through an analysis process whereby the image processing engine will search the captured image for the portion which contains the vehicle license plate number. Once identified, the image will be cropped within the recognition engine itself, removing the other portions of the image which does not contribute to the image processing process.

When the image is left with only the license plate portion, the engine will begin its work by identifying each character present in the cropped image. These characters are identified individually through a process called character segmentation[2].

6 Software Lifecycle

Since this system is only a prototype, we will be using a predictive approach to developing this system since all the modules are already confirmed and verified and no in-between upgrades will be required.
Our project team will be adopting the waterfall methodology for maintaining a steady work process and to ensure that each module will be complete within a given time frame.

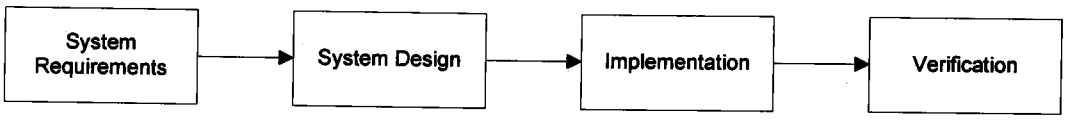

Figure 2. The waterfall model

In the first phase which is the systems requirements phase, all the basic but important functions of the system are verified. In this system, the basic modules which are necessary are the image capturing, image processing, image filtering, data comparison, database connection, log files generator and vehicle tracking modules.
During phase two which is the design phase, the modules will then be used to develop a "blueprint" to be used in the implementation stage. This "blueprint" will set a mainframe for the system prototype to be built upon during the coding process.
After the initial design is completed, only then will the coding be done in the implementation phase. The "blueprint" will provide a plan for all the requirements given during the first phase to be implemented. The disparate modules are coded during the initial stage, and integration is only done towards the final stages of the implementation phase.
At the last phase, the integrated system prototype is tested, debugged and verified of its usability before being confirmed as a working prototype. Here, bug and system defect checks are done to ensure that the prototype is able to function as planned in the requirements phase. This means that the whole prototype must be able to operate as required: the camera captures an image of a vehicle's registration number, the detected characters processed and made into text form which is then used for data comparison in the database for identity verification.

7 Software Requirements Specifications (SRS)

The scope of this project is limited to within the compound of the university. This project focuses on developing a monitoring system which is sufficient and efficient enough to be deployed in the given environment without so much as developing a system that is too complex or which incorporates many unnecessary features that would otherwise render this system redundant feature-wise and demanding in terms of software and hardware requirements.

The system should suffice if it is able to perform the following functions efficiently and effectively:

- Able to detect and distinguish between a vehicle and a non-vehicle object.
- Automatically capture image upon the detection of a vehicle.
- Process the image to single out the license plate number.
- Change or convert the image of the license plate number into text form.
- Use this text form to compare with data in the database to verify the authorization status of the vehicle.
- Display registered and unregistered vehicle license plate number for security purposes.
- Automatically or manually generate reports for security checks or reference.
- Detect where certain vehicles are and displaying their location in the 2D map.

Given the functions above, this sets a guideline for the development of our system as these are the main functions our system is expected to be able to perform. Any other functions that are applicable and able to be incorporated will be assumed under future works.

8 Features/Results

VMS monitors and tracks vehicles coming in and out of the campus ground. Surveillance cameras placed both at the security posts as well as the entrances and exits of the parking areas will capture the image of vehicle license plates as soon as motion is detected. Once captured, these images will be processed and then converted to text. Taking in this converted information as the input, VMS will make comparisons with the existing data in the database to confirm the registration status of the vehicle and validating the vehicle's permission to enter the campus grounds. In short, VMS provides the following:

- Detect vehicle motion as soon as it approaches and exits the campus and parking area
- Capture image of vehicle license plate
- Process the image; converting it to text
- Compare and validate vehicle entry permission
- Automatically open and close bars
- Simulation of vehicles entering and leaving car parks and campus entrances

8.1 The Hallmark of VMS

The trademark of VMS is the easily-recognizable camera window page which is also the main page of this system. As depicted below in Figure 3, there are 4 camera windows; the top 2 are for the gate entrance and exits while the bottom 2 windows are for the parking lot entrances and exits.

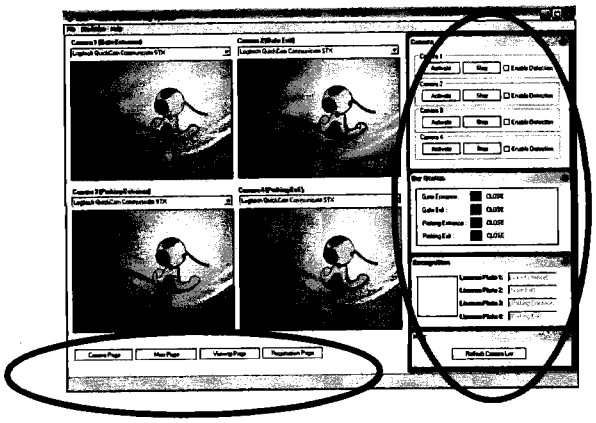

Figure 3. VMS Camera Page

The red circle helps identify the functions of the system which includes the image processing feature. While the entire process processing the data from the captured image is transparent to the users, the results of the converted text will be displayed in the text fields along with the captured image. The security personnel are able to also stop the camera and disabling or enabling the image capturing feature.

There are also 2 additional features of VMS where the system can be linked to the gates to control the opening and closing the gates. Also, whenever there are new cameras installed, the users only need to click on the 'Refresh Camera List' to add and identify them.

The green circle meanwhile indicates the page navigation feature whereby users do not flood the windows taskbar with too many windows opened for VMS. They only need to click on the page they wish to view and the system will only display that page.

8.2 Registration of Vehicles

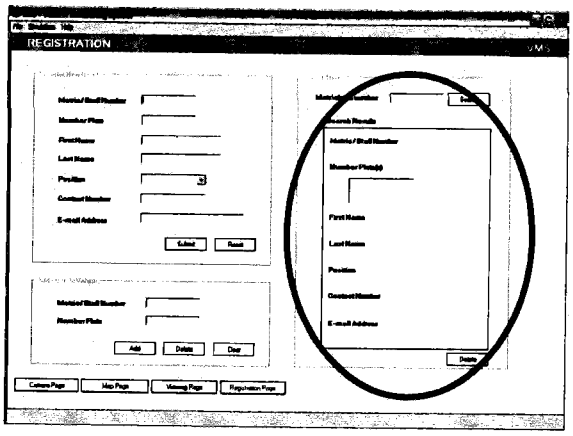

Figure 4. VMS Registration Page

Figure 4 above depicts the registration page where users are able to register their vehicles. This page can also be used by security officers to search for vehicles by the student number and the search results will be displayed in the section marked by the red circle

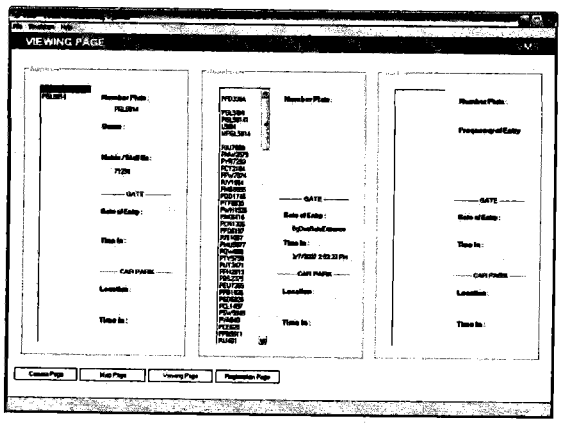

Figure 5. VMS Viewing Page

Figure 5 shows the VMS viewing page. This page is actually part of the registration and database module whereby it allows security personnel to view and identify which of the vehicles is authorized, unauthorized or blacklisted. Security officers will also be able to see the gate where the vehicle enters or exits as well as the time it enters and exits. Detailed information can also be obtained such as the vehicle license plate number and the student ID. Comparing the 3 lists in the viewing page, the blacklisted list have one additional information that can be obtained and that is the frequency of entry whereby after a pre-determined number of allowed entries, the vehicle will be blacklisted.

8.3 Go Interactive with VMS

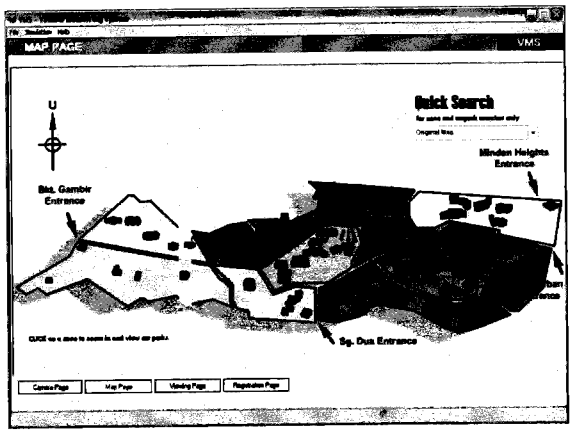

Figure 6. VMS Interactive Map of USM

Figure 6 shows the interactive map of USM where users are able to click on each of the different zones to locate vehicles in major parking lots located within each zone. When a zone is clicked, users will be able to zoom in to get a closer view of the buildings and parking zones as well as locating the vehicles in the parking zones. Users are also able to view the latest images of the major buildings in USM by just moving the mouse pointer over the building.

There is also a feature called the 'Quick Search' where users are able to perform a zonal search for all major parking areas within the campus without having to click on the zones. Once the user has selected the name of the parking lot, they will be taken straight to the correct zone to view the car parks as well as the number of vehicles currently present.

8.4 Generating and Filing Reports and Images

Figure 7 depicts the report page where security personnel can view and generate daily logs to be stored for future references. In the camera page, there will be an option the File menu for users to select in order to go to the report page.

In addition to that, whenever the camera captures the images of the vehicles coming in and leaving the designated areas, these images will be stored in folders generated automatically to be used for future references.

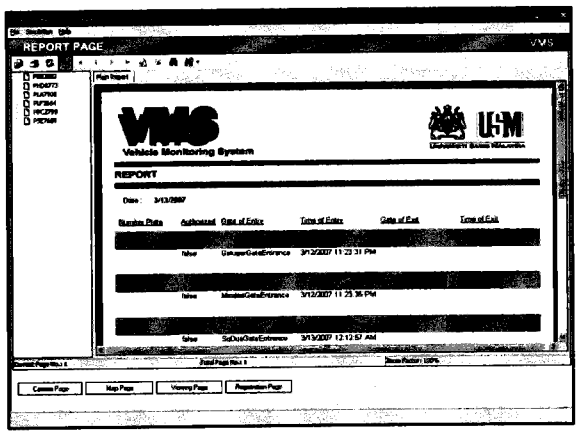

Figure 7. VMS Report Page

9 Discussion

This section produces in-depth discussion on both the motion detection and image processing algorithm as well as providing efficient solutions to solve security issues that are fast becoming a major topic in the world we live in today.

9.1 Motion Detection Algorithm

The motion detection detects movements by comparing each frame when a video stream is recorded in realtime. Each frame will be compared by its pixels to detect the colour changes of the same coordinate. The bigger change signifies a vast movement which triggers the image capturing process. The triggering function will be based on the level of sensitivity.

The main idea behind the motion detection algorithm is by filtering the frames based on algorithms. Most cameras produces images with a lot of noise, so motion is detected although there is no motion. Erosion filter is used to remove random noisy pixels in order to get only the regions where the actual motion occurs.[3]

9.2 Image Processing Algorithm

The image processing feature incorporates a character recognition algorithm which in turn has a smaller branch of algorithm known as character segmentation. The character segmentation algorithm uses edge detection methodology [4] whereby each identifiable character from the captured image will be detected by its edges. Each point around the edges of each character will be identified and detected [5]. Once the edges have been detected, the algorithm shall proceed to identify each character individually. This process is known as segmentation where each character is segmented into rectangular boxes, and identified separately [6]. Once all the characters in the image have been identified, the next stage will be to regroup all the characters together and convert them into text. This converted text will in turn be sent to the system database for verification purposes [7].

10 References

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