

# Patient Room Security and Surveillance

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**Abstract**—This paper describes a vision based simple and secure way of surveillance in the patient room. The surveillance of any sections in the patient room will be monitored using a camera to trigger an appropriate alert to the interested person. Video should be acquired from the camera extracted to frames then the video frames processed where the action has detected in the region of interest. Background subtraction technique used to detect an action in the coordinates given in the video sequence. If any action is detects in the given coordinates, software will examine the situation and alert is send via short message service (SMS) over global system for mobile communication (GSM) network because of its highly availability, security and just in time process.

**Index Terms**—Background subtraction, image processing, patient room monitoring, patient room surveillance.

## I. INTRODUCTION

Today, Image processing is a rapidly growing area of computer science. Its growth has been supported by technological advances in computer processors, digital imaging, and mass storage devices. So, traditionally used analogue imaging are now switching to digital systems, because of their flexibility and affordability. Important examples can be seen in medicine, photography, film and video production, security monitoring, surveillance and remote sensing.

This is to articulate the techniques involved that for patient room security that how it will detect the action in the region of interest. This paper will give the explanations to the image processing concepts in the field of surveillance and triggering specified alert by sending SMS communication via GSM Modem. Step by step methods of the techniques used and corresponding results is provided following chapters.

## II. IMAGE PROCESSING FOR DECISION MAKING

The aim was make a decision depends on the video stream, so the captured frame must be processed step by step to get a binary image. The block diagram of processing is shown in the Fig. 1. Step by step procedure contains the following key points:

- Capture background image ( $t=0$ )
- Apply Greyscale to background image ( $t=0$ )
- Capture frame image in given interval ( $t=t_i$ )

- Apply Greyscale to captured frame image ( $t=t_i$ )
- Subtract background image from captured frame ( $t=t_i$ )
- Apply thresholding technique ( $t=t_i$ )
- Apply dilation technique ( $t=t_i$ )

where  $t$  is time,  $t_i$  is time on  $i^{\text{th}}$  interval,  $I$  is  $i^{\text{th}}$  interval and  $t_c$  is interval time constant.

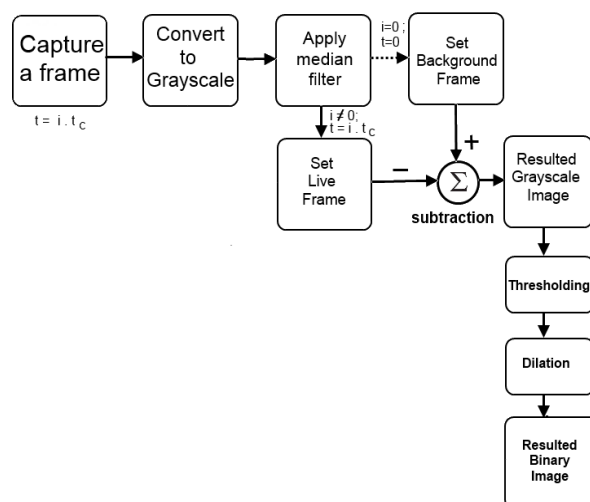


Fig. 1. Image capturing and processing model for decision making.

The selected method in the thesis for the surveillance application is usually known as background subtraction(BS), which is use to segmenting out objects of interest in a scene. This technique involves subtracting an observed image from a static image (background image). To reduce noise and distortion median filtering must apply to captured frames. In the second step images must convert to gray scale to make comparison efficiently. After completing the BS, thresholding must apply to binary comparison. To make the result certain Dilation techniques applied to make the final decision.

### A. True Colour to Gray Scale Conversion

Conversion of a colour image to greyscale is not unique. But the common strategy is to match the luminance of the grayscale image to the luminance of the color image. For digital formats following CCIR 601 [1] (i.e. most digital standard definition formats), luma is calculated with the formula

$$Y' = 0.299 R + 0.587 G + 0.114 B$$

### B. Median Filtering

Median filtering is a nonlinear method which used to remove noise from an image [2]. This technique is widely used and it is very effective method to removing noise while preserving edges. That is effective at removing salt and pepper type noise. Median filter replaces each pixel value

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with a median value of neighbouring pixels. The group of neighbours pixels called as window. The median value is calculated by sorting all the pixel values in the window on ascending order, and replacing the pixel with the middle pixel value which called as median.

C. Background Subtraction

The processing of a video stream to segment foreground objects from the background (BG) is the first step in many computer vision applications. The background subtraction (BGS) technique is a commonly used technique to achieving this segmentation. The BGS largely prefers because of its computational efficiency, which allows applications such as video surveillance, human-computer interaction and traffic monitoring to meet their real-time goals. To improve the results there are some of the pre-processing and post-processing techniques applied to subtracted image.

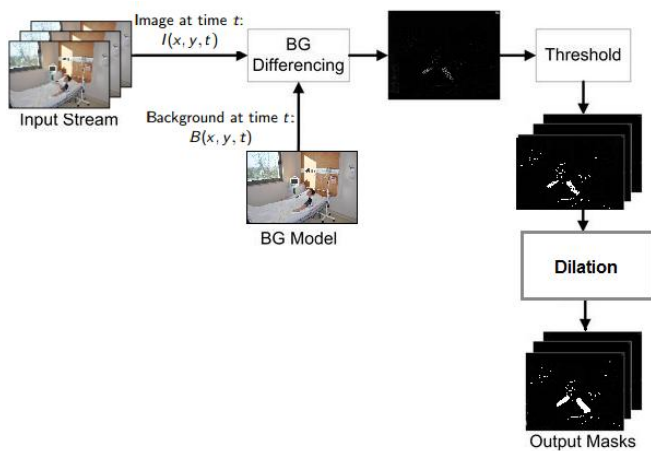


Fig. 2. Frame processing scenario.

Simple Approach is:

- 1) Capture the background for time  $t$ .
- 2) Subtract the captured background from the input frame.
- 3) Apply a thresholding, for the absolute difference to get the foreground mask shown in Fig. 2.

D. Thresholding



Fig. 3. (a) Gray Scale image, (b) Binary Image by thresholding, (c) Dilation: a 2x2 square structured [4].

In the simplest implementation, the output is a binary image representing the segmentation. White pixels correspond to foreground and black pixels correspond to background. Pixel calculation depends on a single parameter known as the intensity threshold. Each pixel in an image is calculated by comparing with this threshold. If the intensity is higher than the threshold the corresponding pixel is set to white at the output. If it is less than the threshold, it is set to black. Fig. 3 shows that what happens when the thresholding applied to gray scale image obtained by background subtraction [3].

E. Dilation

Dilation technique adds pixels to the boundaries of objects in the image to get stronger output. In the Fig. 4 shows a good example of the 3x3 square structured dilation applied.

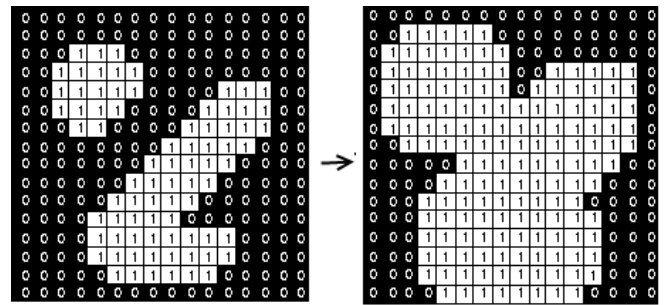


Fig. 4. (a) original image , (b) 3x3 Dilation applied [5].

III. SYSTEM DESIGN AND IMPLEMENTATION

A. Hardware

PC board and its peripherals are used to reduce complication. PC board is prepared to load windows XP system and decision making software running on XP which will control all the process. The basic block diagram and design are shown in the following Fig. 5. The hardware specification used in design is

- PC Board
- Keyboard and Mouse used to control software
- Monitor connected to display outputs, and making visual settings.
- HDD connected to store necessary software
- 1 GB of RAM assembled.
- 300Watt Power Supply Unit (PSU) used to support necessary energy for both GSM Modem and PC Board with Peripherals
- GSM Modem connected to board using RS232 port to send SMS via GSM network in secure and trusted way.
- Basic USB camera connected to board to capture necessary images. (But, good quality camera will give the best performance; try to explain on result part.)

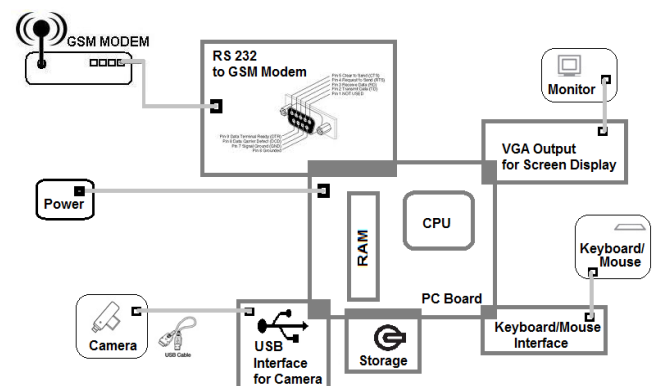


Fig. 5. Basic hardware schematic.

As shown in hardware schematic, Camera connected to PC board via USB interface to capture video frame. Each captured frame processed by software which runs on PC Board/CPU /Ram. The process controlled via keyboard and mouse vis PS/2 interface. The output, visual alert and

changes appears on the VGA monitor via VGA interface. If any changes considered and alert triggered, software calls the GSM Modem routine to fire SMS message. Vice-versa, any response or query can be get via GSM Modem to call appropriate special functions.

*B. Software Design*

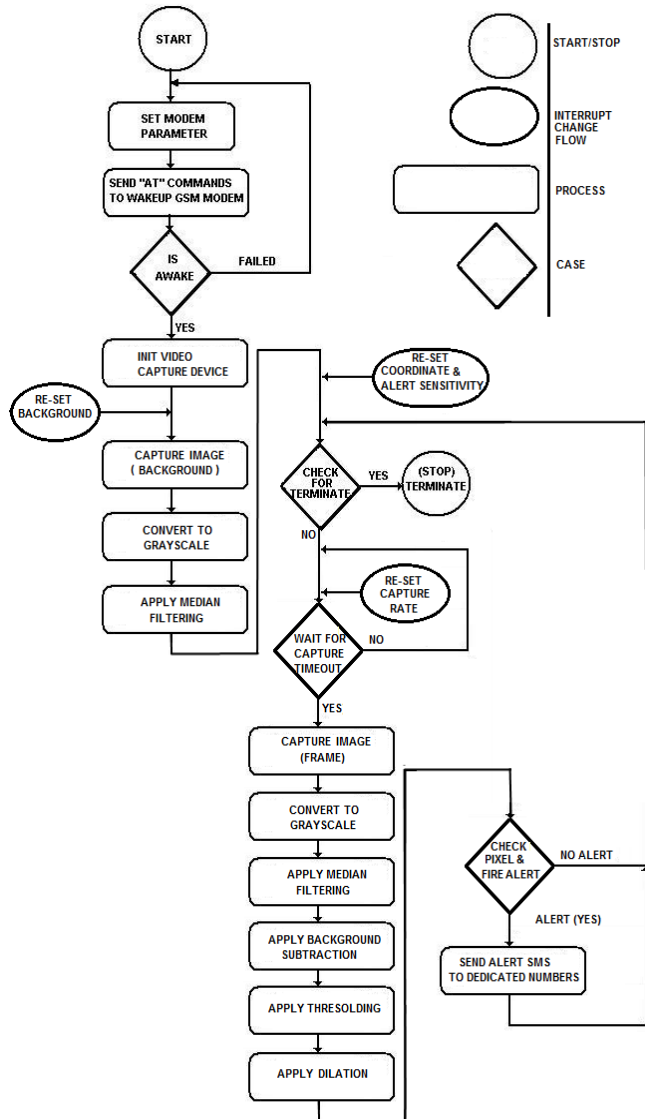


Fig. 6. Software flow-chart.

When software runs, the modem parameters are set via AT commands and RS232 port, in that way modem should be ready to communicate GSM network. If it is failed to connect to network, software will wait until GSM Network available. After negotiate GSM network, the frames start to be capture via Video camera and usb port. When the first frame captured it should be set and store as background image. On the next step, it should be converted to grayscale as described in part II. If any distortion on the medium or usb communication (which is unusual, but worst case scenario), median filtering applied to gray scale background image described to get a smooth and undistorted image. This flow can be call any time of the process if some changes happen on the background which is not related to interest area. As an example, If any changes happen on illumination on the day time, background can be reset using this procedure.

Secondly, Interest region coordinate must be set as square (x1, y1) and (x2, y2). After each region entered, software starts to check are there any changes happened on that region. If somewhere on the detection process any terminate interrupt taken, flow jump to terminate step and detection process will be end.

After each frame captured from the camera, will convert to gray scale. Then median filtering rules should be applied to gray scale captured frame for smoothing and undistorted imaging. Then Background Subtraction technique will apply to find any changes between frames. But to make a decision that is not enough because the pixels must contain 1(one)s and 0(zero)s. So thresholding will apply to subtracted frame. In that way, all the pixels on subtracted frame should be contained 1 and 0. Finally, Dilation will apply to make the result much more clear for the decision process.

After this stage, the software will check any percentages of whites (1-one-s) available in the given square coordinate. If it is more than threshold it will fire an appropriate alert. Alert may be a text message to inform someone via GSM modem or activating any electronic switch to connected to the hardware. Also, that is possible to make a query to the system via SMS Text to take the information about the current status of patient room. And that is possible to run any hardware via SMS text. But in the case stated on thesis focused on mono direction alert, so all alerts are belongs to sending SMS text message to warn or inform someone for the emergency case. But if that is interesting for the future work, necessary codes can be found in the appendix as an example.

Finally, the flow loop turns back to the new frame capture process. That is continuing up to any interrupt request via keyboard or mouse. All the flows of software like shown in the Fig. 6.

*C. Software Application*

When the software initialized the camera and started to capture the background for background subtraction technique. Then program starts to wait for to press set area button. If any area set by a person who controls the software, the process start to detect changes on that area. For the area which selected by the person, following step by step procedures apply to detect any changes. The block diagram of the process can be summarized like shown in the Fig. 1.

To run the software, some parameter must be set properly to run process correctly. When the software runs, it will set the modem on the background. And Interface will pop up like on the Fig. 7. When interface appear, the following must be set

- 1) Refresh Rate (delay to capture next frame)
- 2) Thresholding level
- 3) Alarm sensitivity (percentage of white pixels)
- 4) Coordinate for the surveillance

After set all those parameters properly, "Connect to Cam" button will start to process. On each level of the process will be seen on the interface view (Fig. 7).

Video taken from the camera should be extracted than will be processed to find any action n has been detected in the region of interest. Background subtraction technique was the most involved technique used in the thesis. After retrieving the coordinates of action, the software will examine whether

the action is in the region of interest or out. If it is in the interest area Red(alert) square has drawn around the interest

area if not green(secure) square appears that likes in the Fig. 8.

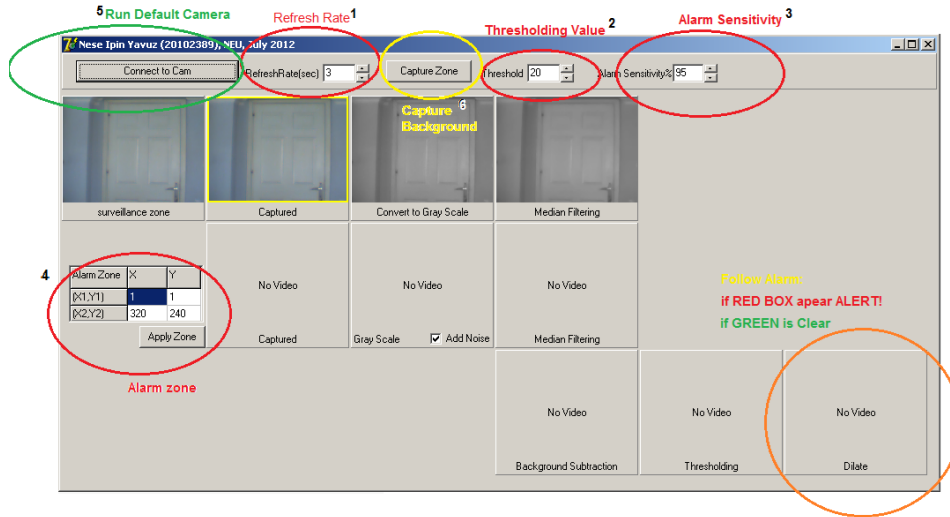
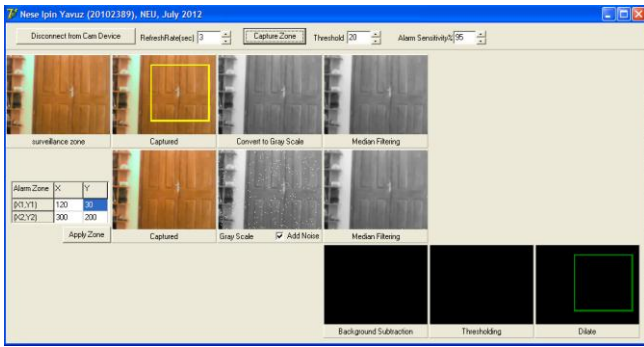
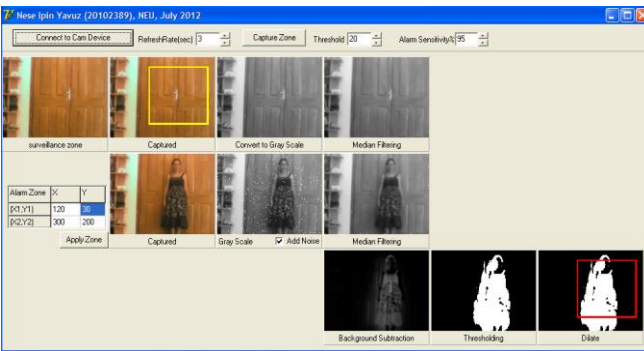


Fig. 7. Software interface view on basic mode.



(a) no action



(b) Human detected at the door.

Fig. 8. Software interface view on detection process.

#### IV. RESULT AND COMMENTS

After complete basic steps to detect the object in the area of the interest, complex software developed to detect multiple area and sending SMS alert over gsm network. Using advantages of GSM network alert should reach to the dedicated person or group in secure and trusted way.

In this scenario, seven square coordinates defined for areas of interest. Those coordinates defined as:

- 1) Face movement detection
- 2) Left hand movement detection & Oxygen probe connection check
- 3) Right hand movement detection
- 4) Probe connection check
- 5) Window opened alert

- 6) Intravenous solution empty alert
- 7) Lights off or Electricity cut off check

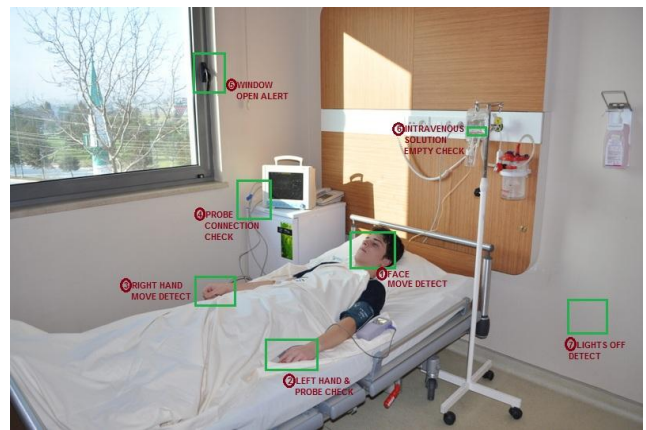


Fig. 9. Patient Room scenario.

On time  $t=0$ , initially background image captured from camera source like shown in the Fig. 9 and 10.

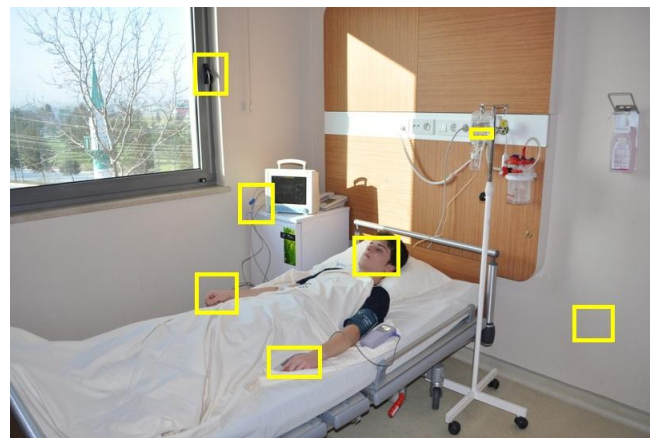


Fig. 10. Patient Room background image and trap locations.

For the later comparison on background subtraction technique, it is converted to gray scale which shown in the Fig. 11.

On time  $t=t_i$ , Right hand movement can be seen easily like

in the Fig. 12. But there is more than this movement which can not be seen easily with human eye. On Final stage shown that the software detected there are more than one move.



Fig. 11. Gray scale conversion applied to background image.



Fig. 12. On time  $t_i$  a frame captured.

And gray scale conversion applied to the image to make a comparison with background image like show in the Fig. 13.



Fig. 13. Background subtraction applied ( $t=t_i$ ).



Fig. 14. Thresholding applied ( $t=t_i$ ).

To make a decision by the software, gray scale image must be converted to binary image which consist of 1s and 0s. The thresholding applied on gray scale on  $t=t_i$  like shown in the Fig. 14.

Before the final decision making stage dilate procedure (8 pixel) applied to get more certain results.

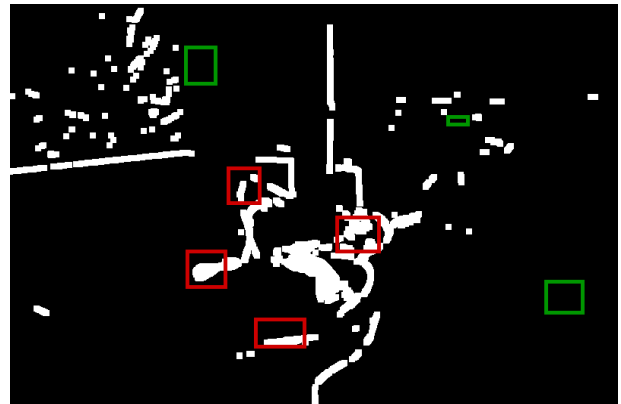


Fig. 15. 8 pixel Dilate applied ( $t=t_i$ ).

Finally four alerts fired which are 1, 2, 3 and 4 described in the Fig. 9. There are no movement detection on coordinates 5, 6, 7. Alerts triggered on the final stage can be shown in Fig. 15 and 16 as Red square. Also note that, Green squares denotes no action detected.

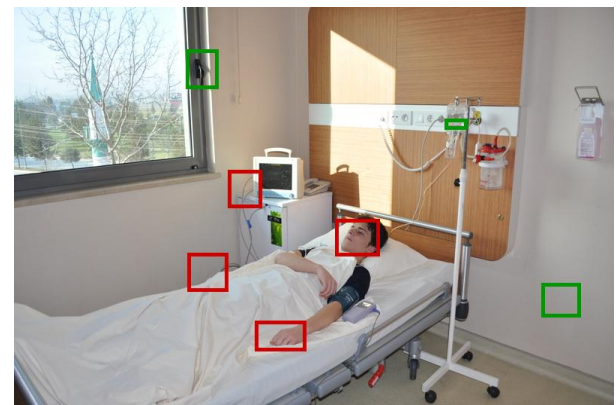


Fig. 16. Changes detected on the area of interest ( $t=t_i$ ).

As shown in Fig 16. Four types of SMS send over the GSM network and dedicated person notified which appears on software screen as red squares. Types of alerts are:

- 1) "Face movement on room 201" to doctor.
- 2) "Oxygen sensor probe problem on 201" to sick nurse.
- 3) "Right hand moved on 201", sick nurse and doctor.
- 4) "Monitor probe disconnected on 201" to sick nurse.

The green squares appear on the software screen which shown in the Fig. 13. It shows that unfired alerts can be listed as:

- 1) "Window opened in room 201" to security and sick nurse.
- 2) "Empty intravenous solution detect on 201" to sick nurse.
- 3) "Lights off or Electric cut in room 201" to sick nurse and maintenance guy.

#### V. ALARM SENSITIVITY AND ERROR CALCULATION

Alarm sensitivity is a threshold parameter that shows the

minimum white pixel ratio percentage in the square area to fire an alert. To detect an alert on the given square area Alarm Level is calculated by

$$\text{Alarm Level} = \frac{\text{White Pixel in the Square}}{\text{Total Pixel in the Square}} \times 100$$

and rule applied to fire an alert.

If Alarm Level > Alarm Sensitivity then fire an appropriate alert

In the patient room application, luminance will not vary with time because of an isolated room for patient health and it is always fixed. So the possible false alert is zero when the alarm sensitivity set to 10 percent in the application that was eliminates all the false alerts error on continues test.

## VI. CONCLUSION

In this paper, try to explain image processing techniques and GSM communication can be combined for the successful application for the patient room security and surveillance system. The demonstration show that this simplest technique also efficient, robust and mobile for this kind of applications. On the final stage of demonstration, it can be seen that it is a helpful system for any hospital to reduce costs and medical complexity. Also it is obvious that it should help to reduce human mistake and application tolerance depends on the tired. On the other hand if this kind of application appears on the hospitals, more jobs can made with less people which also reduces the costs for patient, hospital and also for the governments. The application costs are very feasible and absolutely nothing when the patient live thought.

Finally, a live application completed successfully and showed that it is making the life easy for the people who want

to control to the patient room in secure, efficient, cheap and from very long distances. There is no any alternative (except other GSM services) to surveillance room (without wire) too far away from room point.

## REFERENCES

- [1] International Telecommunications Union, ITU-R BT.601.
- [2] T. Huang, G. Yang, and G. Tang, "A fast two-dimensional median filtering algorithm," *IEEE Trans. Acoust., Speech, Signal Processing*, vol. 27, no. 1, pp. 13-18, 1979.
- [3] N. Otsu, "A threshold selection method from gray-level histogram", *IEEE Transactions on Systems, Man, and Cybernetics*, vol. 9, pp. 62-66, 1976.
- [4] N. Efford, *Digital Image Processing: A Practical Introduction Using Java*, TM. Pearson Education, 2000.
- [5] B. Brown and P. Shilane. Image Mosaic- CS 496 computer vision. [Online]. Available: <http://www.cs.princeton.edu/~pshilane/class/mosaic/>



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