Wireless Webcam Based Omnidirectional Health Care Surveillance System

Wai Kit Wong, Yen Chee Poh, Chu Kiong Loo, Way Soong Lim

Abstract - This paper presents an efficient omnidirectional surveillance system which consists of health care feature. The proposed supervision system is to be used by supervising parties who need immediate informed if there is a human faint. It is usually applied at health care centers like hospital, old folk's home, and handicapped center and is installed at the place under good light condition. In this system, a bracket is designed to attach the hyperbolic mirror face-to-face to the wireless webcam. Therefore, wireless webcam can captures the omnidirectional scene that is reflected into it. A laptop computer performs image processing, on the omnidirectional image for faint detection and alarm purposing. Log-polar mapping is used to unwarp the omnidirectional images into panoramic images. A designed faint detection algorithm is used to detect a fainted person at surveillance site. Alarm is signaled when fainted person detected so that immediate treatment can be done. Experimental results show that the proposed wireless omnidirectional surveillance system has accuracy as high as (92.99% out of 10000 images tested) in monitoring a selected site. This new proposed surveillance system has the features include: small, cost effective, wireless, omnidirectional (360°), produce high compression output image, and has effective faint detection capability.

Keyword - Image processing, omnidirectional surveillance system, Log-polar mapping, Faint detection algorithm, wireless.

1 INTRODUCTION

VIDEO surveillance is a visual observation from a distance in monitoring human's behavior, human's activities or other changing information [1]. Video surveillance system has been found with the greatest research interest in many engineering application such as research interest in many engineering application such as criminal activities detection [2], intrusion detection system [3], public health surveillance system [4] and etc. Conventional video surveillance systems that used in above application need human operator to manually monitor the surveillance video form time to time for event detection. This monitoring task is both boring and mesmerizing [5]. Hence, modern surveillance systems are developed with image processing tools to replace human operator's role in monitoring the video surveillance. Image processing is done on the captured image to detect the specific events and alert the operator when there are specific events occurred.

In spite of the availability of many modern sophisticated surveillance monitoring products in the market, majority of the systems have the limitation in the viewing angle of the camera. A number of researchers had proposed some ways to increase the viewing angle of the surveillance system, which were basically can classified into using mechanical approach and using optical approach. Typical mechanical approaches to improve viewing angle by enhance the surveillance camera are use a number of located regular camera or a single mechanically rotating and moving camera [6]. Besides, some practitioner used wide area surveillance products such as Pan-Tilt-Zoom camera to capture images at monitoring site. A pan-tilt-zoom camera can move back and forth, up and down, and zoom to improve the viewing area. However, the disadvantages of using hardware approaches are expensive hardware cost, and require the use of moving parts and precise positioning to rotate and moving the camera. It needs much time to scan the scenes and synchronize to obtain an omnidirectional image [7].

Another alternative way to capture omnidirectional images is using optical approach. One of them is using fish eye lens. Fish-eye lens provides 360° viewing angle by refract omnidirectional scene into the camera for image acquisition. However, using fish eye lens introduces distortion in the image and the image taken is not immediately understandable because of the geometric distortion [8]. Another suggested approach is by using omnidirectional mirror such as hyperbolic mirror. The 360° omnidirectional scene of the monitoring site is reflected into the camera and the image is captured. Two examples that use hyperbolic mirror in widening the viewing angle are: 1) Integrated surveillance system using multiple omnidirectional vision sensors by Kim et al [9] and 2) omnidirectional surveillance system proposed

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in our previous work [7]. Our previous work is composed of a hyperbolic mirror which is attached face-to-face with the webcam in vertical direction by using a design bracket. It is capable of capturing a 360° area in horizontal plane at a time. In this paper, hyperbolic mirror is used because it is cheaper compared to fish-eye lens with the almost same output image quality.

Due to the geometry distortion, the images captured and need to be unwarpped into understandable image before any processing. Log-polar mapping is used to perform the unwarpping task. It provides both human and image processing tools a full panoramic image so that specific event can be easily detected in the image. The unwarpped image has higher data compression but lower resolution compared to normal video camera image [7,9].

However, in our previous work in [7] uses a wired USB webcam as the imaging device. The length of the USB used is limited due to the signal attenuation. In this paper, we propose a new improvement in which a wireless webcam is used to acquire the omnidirectional image. A wireless webcam provides shorter system setup time than a wired webcam. In contrast to a wired webcam, wireless webcam can be easily installed in difficult terrain. Wireless webcam is also portable and flexible to change such as length extension. Moreover, wireless webcam is ideal for temporary ad hoc such as surveillance during exhibition or sports events [10].

For the health care detection function, a Smart Surveillance System proposed by Lee [11] had applied faint detection in his surveillance system. The proposed Smart Surveillance System by Lee used a wired imaging device to capture images and MATLAB image processing tool to detect a fainted human in a monitored scene at a specific angle, not omnidirectional. It send immediate signal when fainted human detected. The idea is good to implement into our work as the surveillance system is applied in health care center such as old folk's home, hospital, and handicapped center are where the supervising parties need to be informed immediately when human under their care is fainted. Hence, by gathering the previous work listed above, we aim to build a new health care surveillance system that includes these 4 main features: 1) Wide angle of view coverage (360° omnidirectional), 2) Wireless, 3) Captured omnidirectional image is unwarpped into panoramic form, providing user and image processing tools a complete wide angle of view, 4) Effective faint detection that is able to a detect fainted person (old folks, ill-patients) and thus immediate alert/treatment can be carried out.

This paper is organized as below: Section II describes the proposed omnidirectional wireless based surveillance system model. Section III discusses log polar mapping techniques that are used to unwarp omnidirectional images into panoramic form. Section IV summarizes the faint detection algorithm. Section V will show some experimental results and finally in Section VI, we will draw some conclusion and future works.

2. Wireless Webcam Based Omnidirectional Health Care Surveillance System Model

The wireless webcam based health care surveillance system model proposed in this paper is shown in Fig. 1. The system requires a fine resolution wireless webcam, a custom made hyperbolic mirror and a bracket as mirror holder, a wireless router, and a laptop/PC with matlab Ver 2007b programming.

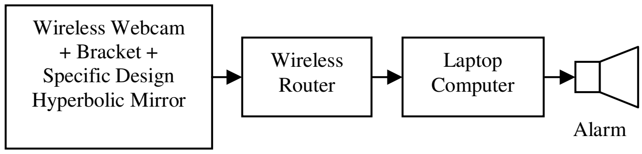


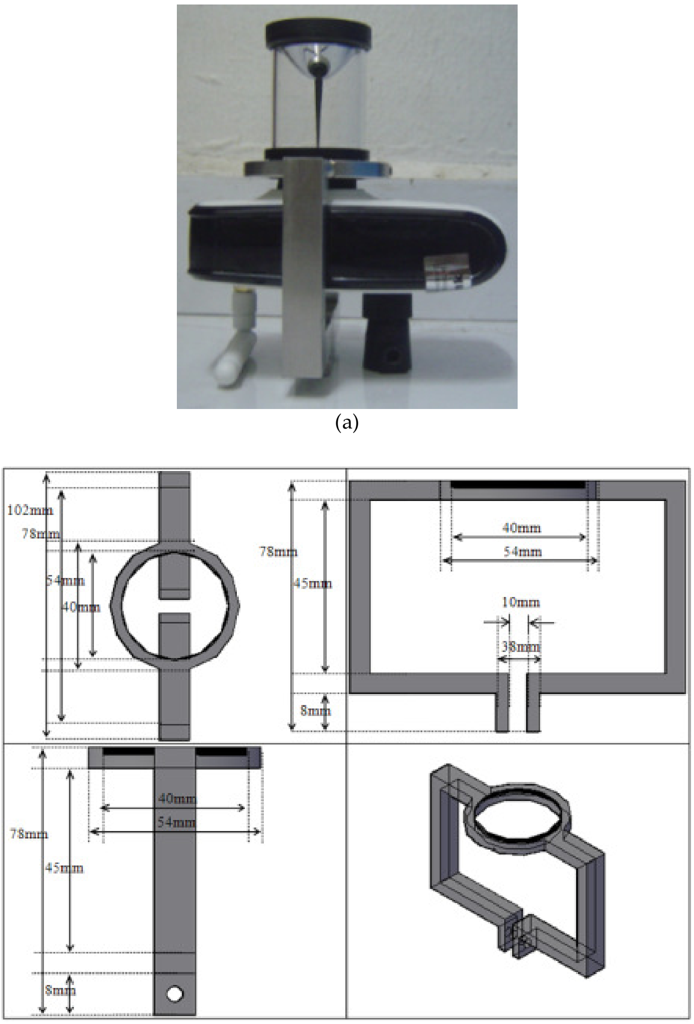
Figure 1. Wireless webcam based omnidirectional health care surveillance system model

A. *Wireless Webcam + Bracket + Specific Design Hyperbolic Mirror*

In the proposed health care surveillance system, a webcam is attached to a specific design hyperbolic mirror with a custom made bracket. The surveillance camera set is shown in Fig.2.(a).The wireless webcam used in this surveillance system is DLink DCS-920 Wireless G network camera. It can capture up to 1.3-Megapixels images. It provides LAN and Wifi connectivity which allows easy connection between PC and the wireless webcam. It can be placed in areas that have no access to Ethernet connection. It can be interfaced with MATLAB and the images captured can be grabbed from the wireless webcam's IP address in the system.

The specific design hyperbolic mirror used in this system is a small size wide view type, with outer diameter 40mm and angle of view 30° above horizontal plane manufactured by ACCOWLE VISION. The mirror reflects surrounding 360° image into the wireless webcam attached to it, and the wireless webcam captures the image and sends them to the laptop computer for image processing.

A custom made bracket is designed to attach the hyperbolic mirror to the camera. A custom made bracket is designed to hold the hyperbolic mirror to the camera. The bracket is made of stainless steel and is designed according to the camera size. The camera size is 75mm x 100mm x 30mm. Since the bracket should stand vertical to camera, the inner size of the bracket should have 75mm x 30mm. The thickness of the steel is fixed at 12mm to provide strong support. A circle with inner radius 20mm and outer radius 27mm is weld on the top of the bracket. The hyperbolic mirror socket which is the place to put the hyperbolic mirror is clamped by two screws to avoid the socket to fall from the bracket. The design of the bracket is shown at Fig.2(b).



(a)

(b)

Figure 2. (a) Surveillance camera set (b) Top, front, side and isometric view of the bracket.

B. Wireless Router

Wireless router acts as a wireless access point. It allows several alternative types of connection between wireless webcam and the laptop computer. The DCS-920 can connect to wireless router either by LAN cable or using Wi-Fi. On the other side, the laptop computer can also connect to the router by using LAN or Wi-Fi. This allows computer without wireless connectivity to access the wireless webcam via LAN connection. Wireless router also allows several PCs which connected to same router to access the captured images. In another way, a computer also can access to multiple wireless webcams image using a wireless router which is mostly used in a control room. With such advantages, the surveillance system can be improved by using several surveillance sets in future research.

C. Laptop Computer

A laptop computer can be used for image processing in the control room. A core 2 dual laptop computer with specs: 2.0GHz processor, 2GB DDR2 RAM is used in this project. MATLAB version 2007b is used as the processing tool for this project. A modified MATLAB image read function is used to access the omnidirectional picture captured from the wireless webcam. Log-polar mapping is used as unwarpping method to transform omnidirectional picture into panoramic form. After that, pre-determined faint detection algorithm is used to process the unwarpped images to detect fainted human in the monitoring site. Alarm will be signaled when there are any fainted human detected.

3. Log- Polar Mapping

Log-polar geometry is a spatially-variant image representation in which pixel separation increases linearly with distance from a central point. It allows concentration of computational resources on a region of interest, and also maintains information from a wider view. Hence, this kind of sampling can reduce the data size by compressing information into low-resolution data [12].

Log-polar mapping is a technique applying log-polar geometry representation. By using Log-polar mapping, an omnidirectional image can be unwarpped into a panoramic image which still keeps the image's quality in data compression mode. This kind of image is preferable for most of the surveillance system to monitor the surrounding objects [12].

The image acquired by using wireless webcam with the hyperbolic mirror is initially in Cartesian form (x_i, y_i). However, the useful information only appears within a circle in captured images. The image will then be sampled by spatially-variant grid into a polar form (ρ, θ) omnidirectional image. The gird is formed by i number of concentric circles with N number of samples each concentric circle. The sampling size is also increase when the sampling point is away from the center point. The sampling period between two consecutive samples is $2\pi/N$ rad. Next, the omnidirectional image is mapped into the Cartesian form (x_o, y_o) accordingly to the coordinate mapping [12].

In this paper, simplified sampling structure is used to improve unwarpping speed. The sampling period in simplified sampling structure is fixed and it does not shifted. The circles sampling shape is also replaced by square sampling shape for easier implementation in MATLAB.

The center pixel for log polar sampling in polar form is described by:

$$\rho(x_i, y_i) = \sqrt{(x_i - x_c)^2 + (y_i - y_c)^2} \quad (1)$$

$$\theta(x_i, y_i) = \left(\frac{N}{2\pi}\right)\tan^{-1}\frac{y_i - y_c}{x_i - x_c} \quad (2)$$

The center pixel for log polar mapping in Cartesian form is described as:

$$x_o(\rho,\theta) = \rho\cos\theta + x_c \quad (3)$$
$$y_o(\rho,\theta) = \rho\sin\theta + y_c \quad (4)$$

where x_c, y_c is the center point of initial Cartesian form coordinate. N is number of angular samples over each concentric circle sample [9]

The process of log-polar mapping is shown in Figure 3. The sampling center point coordinate is calculated by using Equation (1) and Equation (2). The initial image pixel in Cartesian form (x_i, y_i) is transform into polar pixels (ρ, θ) according to the calculated coordinate. This process is named as sampling. The corresponding (ρ_n, θ_n) covers a region of initial Cartesian pixels with radius:[9]

$$r_n = b r_{n-1} \quad (5)$$
$$b = \frac{N+\pi}{N-\pi} \quad (6)$$

where b is the ratio between 2 apparent sampling circles
r is the sampling radius
n is concentric circle from periphery towards fovea, $n = 1,2 \ldots N$

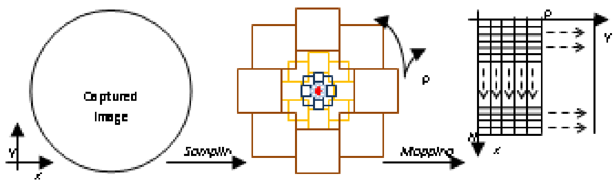


Figure 3: Log Polar Mapping process [12]

Sampling's mean value method is used in this project. The pixel value in each individual polar pixel is equal to the mean pixels value of all pixels within a sampling square on Cartesian form. The mean value of pixels is calculated by Equation (7) and assigned to square sample's center point [12].

$$mean, \mu = \frac{\sum total\ (x_i, y_i)\ pixel's\ value\ within\ a\ square\ sample}{total\ (x_i, y_i)\ pixel\ in\ a\ square\ sample} \quad (7)$$

The mapping coordinate is calculated by using equation (3) and (4). During unwarpping process, the mean pixel's value in polar form (ρ, θ) at sample's center point is mapped into Cartesian form (x_o, y_o) according to the corresponding coordinate. The *x-axis* will mapped with the *θ-axis* while y-*axis* will mapped with the *ρ-axis* .This process is named as mapping and the output of the process will give the system a panoramic wide angle image [12]. Figure 4 shows the square sampling structure in log-polar mapping and the mapping processing.

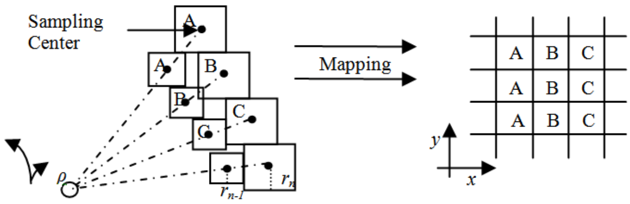


Figure 4: Square sampling structure and mapping process

4. Faint Detection Algorithm

The wireless omnidirectional surveillance system program flow is summarized as below. Firstly, background omnidirectional image is acquired and unwarpped into panoramic image by using Log-polar mapping. After that, input image is obtained and unwarpped into panoramic form. The object appear in the panoramic image is extracted out by using background subtraction method. These objects will be check by faint detection algorithm and classified them as (1) Human faint, (2) Human not faint and (3) not a human. Lastly, action is done by the program according to the output of classification such as (1) Signal alarm (2) Background image update and (3) no action.

The faint detection that used in this system is listed below.

Step 1 : *Background setting*: An on-site omnidirectional image is acquired using the proposed omnidirectional imaging system. The captured image is then converted into grayscale, unwarpped into panoramic form and stored as background image B.

Step 2 : *Application*: A real-time on-site omnidirectional image is acquired continuously. The captured image is then converted into grayscale, unwarpped it into panoramic form and stored as real-time image R.

Step 3 : *Object extraction*: The absolute difference of image pixel values between unwarpped real time image, R with the corresponding pixel value in unwarpped reference background image, B is computed. A binary image is generated according to the computed value.

(i) Define T as the threshold pixel value of the difference between R's pixel at the same coordinate *(x,y)* to B's corresponding pixel at the same coordinate *(x,y)* respectively.

(ii) At each (*x*, *y*) pixel coordinates for R and B, calculate $Q(x,y) = |R(x,y) - B(x,y)|$

(iii) If $Q(x,y) \leq T$, then set $Q(x,y) = 0$; else set $Q(x,y) = 1$, Q is a binary image.

Step 4 : *Object detection and noise cancellation:* There are some of the white pixel that appears in few pixels size. These pixels group are a noise instead of an object. It has a large absolute difference pixel value due to large luminance change at the particular pixel. These non-object pixel groups need to be filtered away to avoid further object classification processing is performed on it to decrease processing time.

(i) From the output binary image obtained in step 3, remove object less than P pixels and fill the removed pixels with 0s(black out), where P is maximum pixels value for noise.

(ii) For each object encounters in the binary image, obtains their boundaries coordinates respectively and store them as $(x_m, y_m)_a$, where m is the length of each object boundaries respectively and a = 1,2,…A is index of object and A is total number of objects exist in the binary image Q.

(iii) For each $(x_m, y_m)_a$ perform human faint detection as stated in step 5

(iv) If there are no objects detected, proceed to step 7

Step 5 : Human faint detection: Faint detection is performed on each boundaries get from previous stage. There are 3 possible outputs for human faint detection such as (1) Not a human, (2) Non-fainted human and (3) Fainted human. To categorize the objects into above categories, 3 different algorithms is designed to check the objects namely (1) No Faint by Top curve check, (2) Faint by left curve checking and (3) Faint by right curve checking. These 3 algorithms share the same concept that firstly the turning point is obtain, forehead curve is check and lastly two side head curve is obtained.

(A) No faint by top curve checking

(i) Check top turning point of each object:

If $y_{n+1} - y_n < 0$ and $y_{n+2} - y_{n+1} > 0$ then record the top turning point as $(x_{Tp}, y_{Tp})_{b_T}$, where n=1,2,…m-2 and ,b_T=1,2…B_T, is index of top turning point and B_T is total number of top turning points exist in the particular object. An example of searching top turning point is shown at Fig.5.(a)

(ii) From the top turning points obtained in (i), check the top curve for each particular turning point$(x_{Tp}, y_{Tp})_{b_T}$,

if $y_{Tp+k_{Tt}} - y_{Tp+k_{Tt}+1} \leq 1, k_{Tt} = [0, u]$

and $y_{Tp+k_{Tt}} - y_{Tp+k_{Tt}-1} \leq 1, k_{Tt} = [-u, 0)$

then, top curve is true, proceed to (iii);

else top curve = false, proceed to (B)

where, u is the looping variable to find it nearest turning point of the curve

(iii)The following condition is then checked.

$x_{Tp+k_{Tl}-u+1} - x_{Tp+k_{Tl}-u} \leq 1$, k_{Tl}=$[0, v]$ (8)

$x_{Tp+k_{Tl}-u-1} - x_{Tp+k_{Tl}-u} \leq 1$, k_{Tl}=$[-v, 0)$ (9)

$x_{Tt+k_{Tr}+u} - x_{Tp+k_{Tr}+u+1} \leq 1$, k_{Tr}=$[0, w]$ (10)

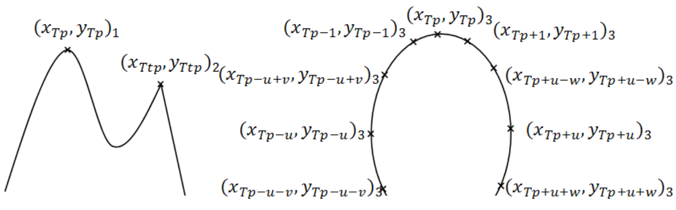
$x_{Tp+k_{Tr}+u} - x_{Tp+k_{Tr}+u-1} \leq 1$, k_{Tr}=$[-w, 0)$ (11)

If condition (8),(9),(10), and (11) fulfilled, object is defined as 'no faint human', else it is not a human, where

L_{min}<v+u<L_{max} is left curve length of the curve.

L_{min}<w+u<L_{max} is right curve length of the curve.

L_{min} and L_{max} is threshold range for curve that determines it is a curve. An example of no faint by top curve checking is shown at Fig.5.(b)



(a) (b)

Figure 5.(a) Searching top turning point (b) No faint by top curve checking

(B) Faint with left curve checking

(i) Check left turning point of each object:

If $x_{n+1} - x_n < 0$ and $x_{n+2} - x_{n+1} > 0$ then record the left turning point as $(x_{Lp}, y_{Lp})_{b_L}$, where n=1,2,…m-2 and b_L=1,2…B_L, is index of left turning point and B_L is total number of left turning points exist in the particular object. An example or searching left turning point is shown at Fig 6(a)

(ii) From the left turning points obtained in (i), check the left curve for each particular turning point$(x_{Lp}, y_{Lp})_{b_L}$,

if $x_{Lp+k_{Lt}+1} - x_{Lp+k_{Lt}} \leq 1, k_{Lt} = [0, u]$

and $x_{Lp+k_{Lt}-1} - x_{Lp+k_{Lt}} \leq 1, k_{Lt} = [-u, 0)$

then, left curve is true, proceed to (iii); else left curve = false, proceed to (C)

(iii)The following condition is then checked.

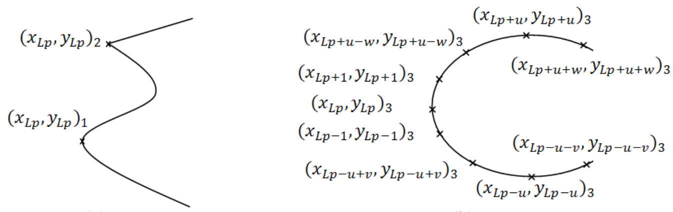
$y_{Lp+k_{Ll}-u} - y_{Tp+k_{Ll}-u+1} \leq 1$, k_{Ll}=$[0, v]$ (12)

$y_{Lp+k_{Ll}-u} - y_{Tp+k_{Ll}-u-1} \leq 1$, k_{Ll}=$[-v, 0)$ (13)

$y_{Lp+k_{Lr}+u+1} - y_{Lp+k_{Lr}+u} \leq 1$, k_{Lr}=$[0, w]$ (14)

$y_{Lp+k_{Lr}+u-1} - y_{Lp+k_{Lr}+u} \leq 1$, k_{Lr}=$[-w, 0)$ (15)

If condition (12),(13),(14), and (15) fulfilled, object is defined as 'fainted human', else it is not a human. A example of human faint by left curve checking is shown at Fig.6.(b)



(a) (b)

Figure 6.(a) Searching left turning point (b) human faint by left curve checking

(C) Faint with right curve checking

(i) Check right turning point of each object:

If $x_{n+1} - x_n > 0$ if $x_{n+2} - x_{n+1} < 0$ then record the left turning point as $(x_{Rp}, y_{Rp})_{b_R}$, where n=1,2,…m-2, and b_R=1,2…B_R, is index of right turning point and B_R is total number of right turning points exist in the particular object. An example or searching right turning point is shown in figure 7a

(ii)From the right turning points obtained in (i), check the right curve for each particular turning point $(x_{Rp}, y_{Rp})_{b_R}$,
if $x_{Rp+k_{Rt}} - x_{Rp+k_{Rt}+1} \leq 1,\ k_{Rt} = [0, u]$
and $x_{Rp+k_{Rt}} - x_{Rp+k_{Rt}-1} \leq 1,\ k_{Rt} = [-u, 0)$
then, right curve is true, proceed to (iii); else right curve = false, proceed next step

(iii)The following condition is then checked.

$$y_{Rp+k_{Rl}-u+1} - y_{Rp+k_{Rl}-u} \leq 1,\ k_{Rl}=[0, v] \quad (16)$$

$$y_{Rp+k_{Rl}-u-1} - y_{Rp+k_{Rl}-u} \leq 1,\ k_{Rl}=[-v, 0) \quad (17)$$

$$y_{Rp+k_{Rr}+u} - y_{Rp+k_{Rr}+u+1} \leq 1,\ k_{Rr}=[0, w] \quad (18)$$

$$y_{Rp+k_{Rr}+u} - y_{Rp+k_{Rr}+u-1} \leq 1,\ k_{Rr}=[-w, 0) \quad (19)$$

If condition (16),(17),(18), and (19) fulfilled, object is defined as 'fainted human', else it is not a human. A example of human faint by right curve checking is shown at Fig 7(b)

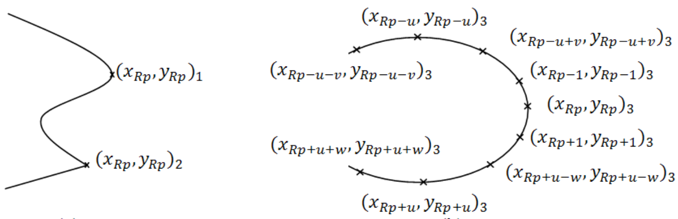


Figure 7(a) Searching right turning point (b) human faint by right curve checking

Step 7 : *Result classification:* Action is done by the program according to the output of classification

(i) No faint human
Green box is drawn on the human head according to *u,v,w* point from object detection section. "No object counter" is reset. The objective of having this class is just to avoid background reference is updated with human inside the place. It is because when there is a human at the background image, the algorithm will be disturbed.

(ii) Faint human
Red box is drawn on whole human body according to maximum and minimum point of *x,y* coordinate from object detection section. If fainted human is detected, alarm is signaled and the "No object counter" is reset.

(iii) Non-human
"No object counter" is increment by 1. When the "No object counter" is equal to 3, which mean there are no object detected or "Non-human" is detected in 3 continuous images. Hence, the background image B, is updated by replacing with current image R. This step successfully tracks the instantaneous luminance changing of background image.

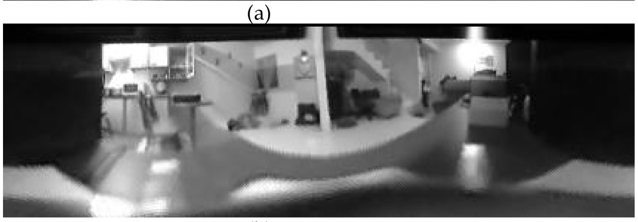
5. Experimental Results

In this section, we briefly illustrate the application of the proposed wireless webcam based omnidirectional health care surveillance system. For log-polar mapping, we have chosen N=427 because the omnidirectional image is cropped with dimension 427×427. Fig.8.(a,b) show an omnidirectional image with a human and with a fainted human in the same room respectively. Fig.9 (a) and Fig.9 (b) show the panoramic image unwarpped from Fig.8(a), and Fig.8(b) respectively. When the system detected fainted human, it will send alarm so that treatment can be delivered immediately. We can observe that Fig.8(a,b) are with resolution 427x427 while the panoramic form in Fig.9(a,b) are with resolution 427x131. This means that the mapping scale is by 182329: 55837, with 3.265 fold of data reduction.

(a) (b)

Figure 8. (a) Omnidirectional image with a human (b) Omnidirectional image with fainted human

(a)



(b)

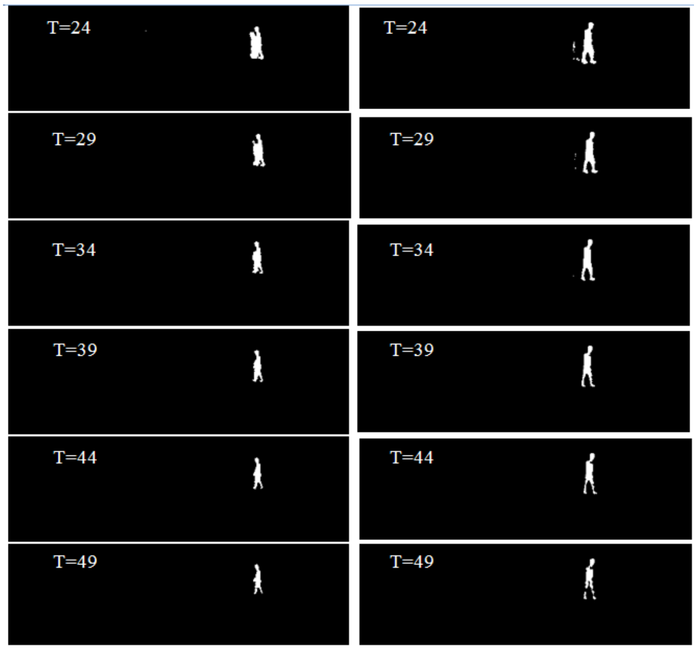
Figure 9.(a) Panoramic image with human (b) Panoramic image with fainted human

To achieve high accuracy of faint detection, there are 4 parameters to be optimized, such as threshold value for object differentiation and binary image conversion T, maximum noise pixel P, minimum and maximum threshold range for human head detection L_{min} and L_{max}. To obtains the optimum value above parameters, an experiment is conducted in a room with a human exists within 3 m range from the wireless camera. 1000 images are captured and unwarpped to acquire panoramic images.

Threshold value T is the most important among all parameters. It is because all parameters are depending on predetermined T value. To obtain the optimum T value, 2 panoramic images with a human at different distance is run with different value of T. Fig 10 shows the normal image of 2 comparison image. Figure 4.11 shows the binary image with different T value processed from images from Figure 4.10.

(a) (b)

Figure 10: Normal image for (a) far object (b) near object



(a) (b)

Figure 11: Object with different T value (a) far object (b) near object

Table 1: Similarity of the object's shape with the normal image object

Threshold Value T	Far Object	Near Object
24	Not Same	Not Same
29	Not Same	Not Same
34	Not Same	Same
39	Same	Same
44	Same	Same
49	Same	Not Same

From the binary image shown in Figure 11, the similarity of the object's shape with the normal image object shape is listed in Table 1. According to the table, the T value that can be used in the system to detect both far and near object is fall between 39 and 44. So the following test, the T value is set to 44.

The maximum noise pixel P is same as the minimum pixel value of a detectable human in the image. The number of pixel of a detectable object less than P will be considered as non-human or noise. To determine the value of P, 1000 images are tested and the number of pixel of a human is obtained. A histogram is plotted according to the human pixel in the image as shown in Fig 12. Form the histogram, the human's pixel value usually will have the value greater than 150 pixel. So the P value is set to 150. The object detected that have pixel size less than 150 will be consider as noise and will be removed during image processing.

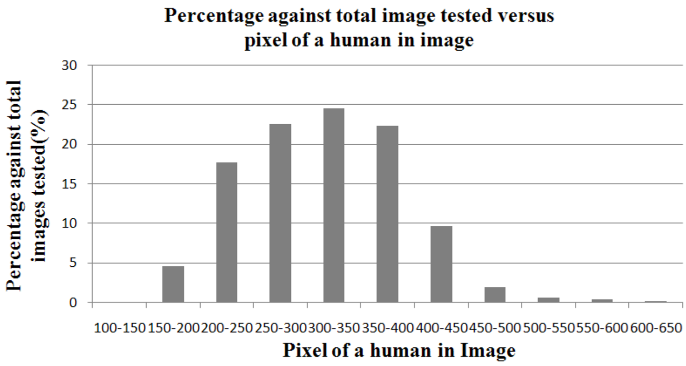


Figure 12: Probability distribution of pixel of a human in tested image

For the L_{min} value, the algorithm is tested with human walking and faint at the place far away from the camera. When an object is far away from the camera, the object pixel will also decrease. The minimum threshold range for human head detection L_{min} must be decrease in order to detect the faint human or non-fainted human at far location. However, the decreasing the L_{min} value will provide fault detection when detecting non-human object. So the optimum value should be obtained in order to improve system accuracy. 1000 samples are captured with human walking and faint at distance 3m-4m from the camera. The detection accuracy is obtained for $L_{min} >$ 1,2,3,4 and 5 as the length of side curve. Graph accuracy versus L_{min} value is plotted in Fig 13. From the plot, the optimum L_{min} value is 2 with highest accuracy 93.8%.

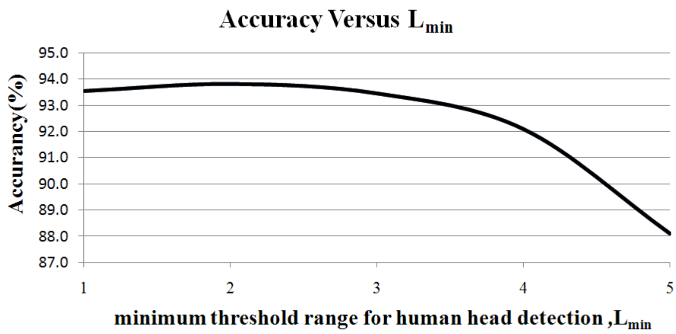


Figure 13: Graph accuracy versus minimum threshold range for human head detection

For the L_{max} value, the algorithm is tested with human walking and faint at the place near to the camera. When an object is near to the camera, the object pixel will also increase. The maximum threshold range for human head detection L_{max} must be increase in order to detect the faint human or non-fainted human at near location. However, the decreasing the L_{max} value will provide fault detection when detecting non-human object. So, the optimum value should be obtained in order to improve system accuracy. The experiment to obtain L_{min} is repeated with 1000 samples which are captured with human walking and faint at distance 2m-3m from the camera. The detection accuracy is obtained for $L_{max} < 24,25,26,27$ and 28 as the length of side curve. Graph accuracy versus L_{max} value is plotted in Figure 4.17. From the plot, the optimum L_{max} value is 27 with highest accuracy 92.7%.

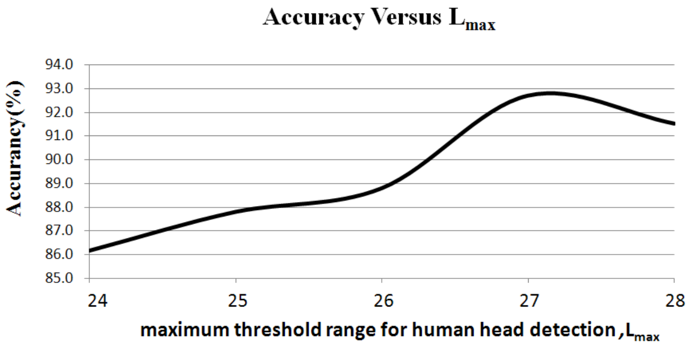


Figure 14: Graph accuracy versus minimum threshold range for human head detection

After obtaining all the parameters, the performance of the wireless webcam based omnidirectional surveillance system is evaluated. A total of 10000 samples images which include without human, with human, with fainted human and other objects at different distance form camera. These images are evaluated by both faint detection algorithm and human operation. The condition that agreed by both parties is recorded. The results show that 9299 out if 10000 images were perfectly detect, i.e. an accuracy of 92.99%. The time consumed to perform image acquisition and Log-Polar mapping is 0.0464s and 1.8375s respectively. Whereas, the time consumed for faint detection is 0.3297s. Hence, total routine time for the system to detect fainted human is 2.2136s.

6. Conclusion

In this paper, we have proposed new wireless webcam based omnidirectional health care surveillance system. The observed significances of this new proposed surveillance system include: omnidirectional (360°) coverage, wireless, high data compression output images, and with effective faint detection capability. Experimental results show that the proposed system achieves high accuracy of 92.99%.

In future, thermal imaging apparatus can be embedded onto the same surveillance system for detection in outdoor environment where the lightning condition is natural varying, and also in night vision. The thermal camera measures the radiated infrared energy of the object and then converts data to corresponding map of temperature. Object with higher temperature will radiate more infrared energy and give brighter color in image. Whereas object with lower temperature will radiate less infrared energy and give darker color in image. With such an advantage, thermal camera parameter can tuned to operate at the human temperature. The object that fall between the ranges will be captured and image processing can be applied for human faint detection. Besides, a mobile robot can be build for moving around the site carrying such wireless surveillance system. The wireless camera power is design to be supplied by a battery instead from a power plug. It allows the robot to carry the surveillance camera set without limitation of the power cables' length. By using a mobile robot, several sites can be monitored by using only one omnidirectional system. Moreover, An FPGA board is planned to propose for replacing laptop/PC, since FPGA board is much lighter space utilization lesser, cheaper, faster processing speed and faster reset time (boot time) in compare to laptop/PC. These topics will be addressed in future work.

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