Elevator's External Button Recognition and Detection for Vision-based System

Wan Nur Farhanah Wan Zakaria
Faculty of Electrical and Electronic Engineering
Universiti Malaysia Pahang
26600 Pekan, Pahang, Malaysia
farhanah_zakaria@yahoo.com

Mohd Razali Daud
Faculty of Electrical and Electronic Engineering
Universiti Malaysia Pahang
26600 Pekan, Pahang, Malaysia
mrazali@ump.edu.my

Saifudin Razali
Faculty of Electrical and Electronic Engineering
Universiti Malaysia Pahang
26600 Pekan, Pahang, Malaysia
saifudin@ump.edu.my

Faculty of Electrical and Electronic Engineering
Universiti Malaysia Pahang
26600 Pekan, Pahang, Malaysia
mfadhil@ump.edu.my

Mohammad Fadhil Abas

Abstract— *Recently, autonomous transporter offers the assistance and delivery for user but they are only focusing on single floor environment. To widen up fields of robotic, they teach robot to use an elevator because elevator provides an essential means of faster movement across level. However, most of the mobile service robot failed to detect elevator's position due to the complex background and reflection on the elevator door and button panel itself. This paper presents a new strategy for recognition method to detect elevator by detecting their external button efficiently. Sobel is use as edge detection operator to find the estimated absolute gradient magnitude at each point in an input grayscale image. Then, but we enhanced the technique by combining it with wiener filter to reduce the amount of noise present in a signal by comparing the signal with an estimation of the desired noiseless signal. This filter helps to eliminate the reflection image on elevator's button panel before it can be converted to black and white image (binarization). The process followed by some morphological and structuring elements process. Tests have been done and the results shown that elevator's external button can be recognized and detected by those entire framework.*

Keywords— Elevator's external button, Sobel operator, complex background, reflection image

I. INTRODUCTION

The evolution of performances for autonomous transporter constitutes one of the major trends in the current research fields regarding robotics. This tendency is motivated by the current gap between the currently available technology and the new application demands. Most of the robotic researchers focus on the autonomous navigation[1] [2][3] and obstacle avoidance[4][5] but they unable to applied it when mobile robot need to move in multi-level of floors such as hospital. There have two choices for robot to move from different level of floors which are by using stairs or an elevator. However, for the contemporary hospital environment, the robot requires elevator to move to different level of floors as the tendency for robot to collapse/falling down while using stairs are high due to high quantity of users and the conditions of stairs itself. So, service mobile robot needs elevator operation to be able to moves from location A to location B if the target location is on the different level of floors.

Previous researchers have been discovered on some approaches to localize the elevator which is either by detecting the elevator door or the button panel of the elevator. In detecting the elevator door, various techniques have been used such as using a sensor for example laser scanners[1][6] and by means of vision[7][8], either using single[9][7] or two camera as known as stereo system[10].

Miura et al. [11] proposed interactive teaching for mobile robot by user interfacing. User will point the door of the elevator and robot will find it by using laser scanner. However, this application can't be applied without user interface especially on new environment or buildings. In views of practical robotic vision, the using of disparity map is not too effective for finding an elevator door due to different depth of elevator's front wall to elevator door and unfortunately, some of them have same depth with room's front wall to room door [10].

Several interactive localizing framework have been proposed by detecting elevator's button in order to complete the mission of finding an elevator [6][12][13][6] . Kang et al. [6] proposed method of detecting elevator by using laser scanner to get laser reading of button. However, method used unable to solves the problem when there have some impurities or damaged on button panel itself as shown in figure 1. X.Yu et al. [7] solved similar case where they conducted a study to detecting elevator's button but they are only focusing on detecting internal button, not external as an option.

Figure 1: Three samples of dirty and damaged button panel

In elevator recognition procedure through image processing method, the major problems come from the presence of mirroring effect's by elevator's external button panel due to materials used by that element. Mirroring effect will reflects everything exist within the button panel into the image captured by the camera as shown in figure 2. This unexpected image obscured the real shapes of the target image and makes the process of searching become more challenging to solve and it still can't be totally solves by any researchers yet.

Figure 2: Reflections image of elevator door and button panel

Thus, this paper work aims to contribute significant improvement by developing a framework for vision-based elevator external button recognition and localization in the presence of specular reflections, dirty or damaged conditions. The edge of an image is the most elementary features as they extract the original shape of an object. One of the main complications in digital image processing and environment analysis is the extraction of useful and relevant edges. In this case, the problem is more complex due to reflection (mirroring effect) and cluttered environment that surrounds the elevator button panel as depicted in Figure 2. During the process of recognition and localization, the robot uses a single-camera vision system to find the elevator's external button form / location and analyzing the image through our proposed method. Upon detecting the elements, the mobile robot generates a signal to indicate that an elevator has been detected. Several tests have been conducted on elevator's external button at different locations to assess the functionality of the system. The remaining of this paper is structured as follows; Section 2 gives an overview of elevator's external button recognition process. After that, Section 3 will conclude the overall of the research.

II. METHOD

Elevator's button have two parts which are internal button and external button but this paper only covered for external button panel as internal button panel is not included for elevator's recognition process. Elevators are normally controlled by 2 external buttons to move up or down. The external button may be associated with a group of two or more elevators at a same time to confirm that only one elevator is called at each time.

The robot moves to scan on the surrounding wall to searches for external button image patterns. However, it is difficult to cultivate a general button recognition system as there have several types and appearance of elevators button in Malaysia. Thus, this paper proposed the most basic features to detect and recognized elevator buttons that available.

Most of elevator's button panels are built with the same materials with elevator which are reflective surfaces with mirroring effect. It's become more challenging for an autonomous mobile robot to recognize and detect the real shapes of button panel. Figure 3 shows method applied for button panel detection and recognition. For button panel detection and recognition, image had been captured in the distance of 1.0 to 2.0 meters.

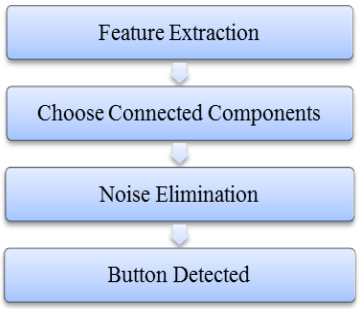


Figure 3: Method applied for button panel detection and recognition

A. Feature Extraction

Feature extraction is a distinctive form of dimensionality lessening. The main objective of this part is to analyse the presence of edge on each image. If the feature extractions processes are succeed, it is expected that the features will extract the important information from the input image in order to execute the desired mission.

Original image will be analyzed to enrich the presence of edges in the current intensity. The quality of edge detection is measured from the amount of information that can be acquired from the processed data. Each type of edge operator has different capability in removing noise from and enhancing the edge of an object. In general, the selection is based on the circumstances of the targeted image and on how much noise is extracted from the x-axis and y-axis. An image of external button was processed with Canny Edge Detection [7][14], Zerocross Edge Detection , Log Edge Detection as well as Sobel Edge Detection [3][10] and been compared. It was found that Sobel edge detection is the most suitable operator as it was able to extract the most parameters from the image. Sobel Edge Detection is more compatible to detect the elevator's external buttons due to its advantages over the other edge detection methods which is Sobel edge detection could afford less noise effect of the captured image. It can be done with the average factor in the Sobel operator. Moreover, the edge can look thicker and bright since the element of the edge

on the both sides had been increased due to the differential of two rows or columns.

The Sobel edge detection's operator does not end the operation lonely but it had been enhanced with the Wiener statistical approach with the help of some morphological operations. Wiener filter is one of the image enhancement processes which are to adjust images so that the results are more suitable for display or further analysis. It needs to be applied to diminish the mean-square error between the undistorted image of the object and filtered image. With the filtered image using Weiner filter, the external button's image be more coherent than before.

B. Connected Component and Noise Eliminations

Before the process of finding connecting component, image that been through the process of Sobel edge detection and Wiener filter is transformed into one bit during binarization process on each pixel of the image. The high value as '1' or low value '0' is assigned upon the mean value of all pixel in the image, and if greater than mean value then its '1', if smaller than mean value then its '0'. Binarization will do the segmentation to the elevator captured image in order to sharing the intensity property. Binarization or also being called with Image Thresholding is threshold a grey-level image to binary image and then separate the captured image from its background.

$$g(x,y) = \begin{cases} 1 & if\ f(x,y) >= T \\ 0 & Otherwise \end{cases} \quad (1)$$

Where T is some of global threshold

The color image that had been captured in RGB form is transform into Black and White image using this binarization technique based on threshold. Its transform all pixel in image to Black (low '0') or into White (high '1') Morphological operation is a broad set of image processing procedures that process images based on shapes. This operation was applied to structure element to an elevator's external buttons image, creating an output image more clearly. This project only applies the most basic morphological operations which are dilation and erosion. Dilation complements pixels to the boundaries of objects in an image to make a line between elevator's button panel and button frames itself that had been erased during Weiner filter and binarization process. Erosion removes pixels on object boundaries for extra thick frames detected. The number of pixels added or removed from the objects in an image depends on the size and shape of the structuring element used to process the image

The process of finding connected components done by scanning above image and clusters its pixels into components based on pixel connectivity. All pixels in a connected component share comparable pixel intensity values and are in some way connected with each other. For this step, all connected component will be obtained as it has a number of required properties for elevator external button detection. Once all groups have been resolute, all connected component will be filled with as it is a set of background pixels that cannot be reached if it still in "hole condition".

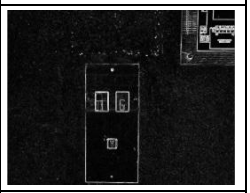
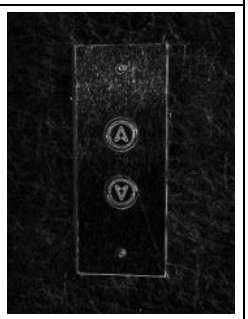
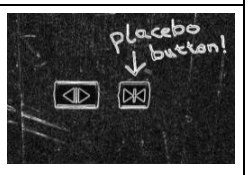
After extracting the connected components, the image still have some noise that can affect the process of finding elevator's button. Even though methods applied for those processes can reduce the general level of noise in the image, considerable noise still remains. To overcome that problem, process of noise elimination had been done by removing non-connected component from the image. By doing this step, all those graffiti, button panel frames, stickers and other unconnected components able to remove from the results images.

The number of elevator's button will be calculated as a reference by applying blob detection method. Blob detection is applied to spot region in a digital image that differs in properties such as brightness or colour compared to areas surrounding those regions. This process become easier when the image is already convert to black and white from the early steps and it is a bonus when there have less noise in the final images before it will be through blob detections process. Total number of blob detected will be count as a reference where most of elevator external button in Malaysia only consist of 2 buttons as an option.

III. ANALYSIS AND DISCUSSION

Feature extraction is represented by Sobel edge detection with the enhancement process by Wiener statistical approach. Table 1 shows three samples of result before and after applying modified Sobel operator. Results displays that image are significantly decrease the amount of data to be treated and might filter out unused information while conserving the main structural properties of an image.

Table 1: Image before and after applying Sobel Operator

Before	After
	
	
	

The process is continued by binarization or in a similar manner to a filter in greyscale image processing. Since the pixels can merely have two values which are either "1" or "0", the morphological operations as erosion and dilation might be add on to enlarge or remove minor holes, eliminate small

substances, and separate objects. Figure 4 and Figure 5 shows binarization image of elevator external buttons as well as the effect of morphological operations on the image.

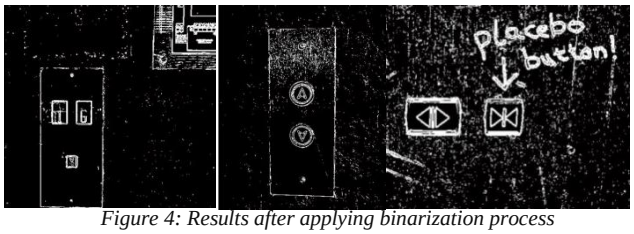


Figure 4: Results after applying binarization process

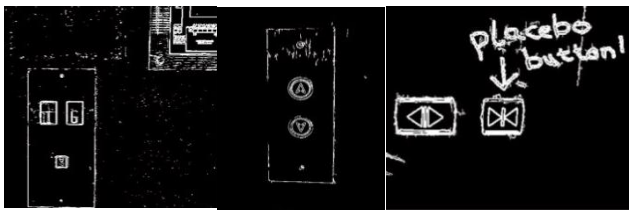


Figure 5: The effect of morphological & structuring elements operations applied

Results as shown in figure 5 display some improvement where more than 50% of small noise successfully diminished from the input images. The process continues with the next method which is gaining all connected component and entirely holes in the image will be filled to make the component more impeccable. Figure 6 shows result after gaining connected component without holes on the image.

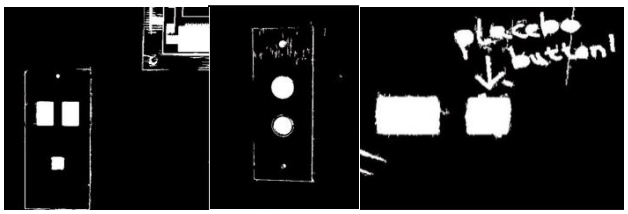


Figure 6: Images after gaining connected components without holes

Based on this analysis, image gained are still in worse condition where there still have some graffiti, button panel frames and some other considerable noise. To remove all unused noise and extract only main element, the process of noise and non-connected component elimination will be done. Figure 7 shows result after removing all noise and non-connected component from the images.

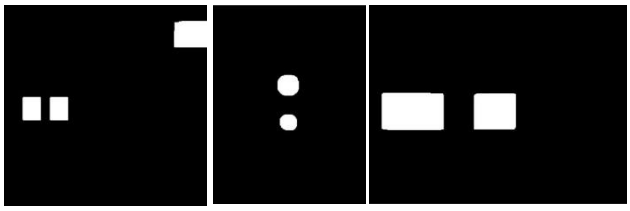


Figure 7: Images after removing non-connected component

In order to count the total number of elevator's external button, BLOB detection method had been applied and figure 8 shows images result with the number of button panel detected from the analysis.

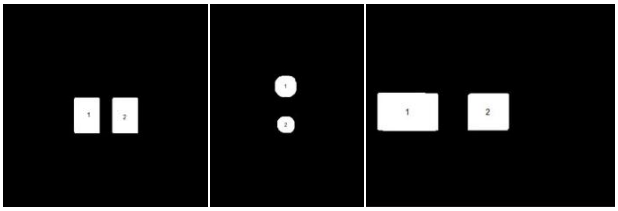


Figure 8: Images with the number of buttons detected

Image of elevator's button panel had been captured on the different scenes and environment to make sure that the service mobile robot are able to run the system on any environment changes. To check the system's ability, we are also testing it on the internal button panel that consists of more than 2 buttons and figure 9 show the image results.

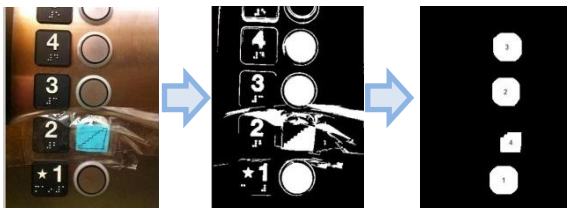


Figure 9: Image result for internal buttons detection

It has been proven that this system is suitable for both internal and external elevator's buttons. Evocative results from some experiments that have been done showing some advantages and disadvantages of the applied method. The experiment has been done by Matlab image processing method on 2048x1560 images dimensions. 50 different images of elevator's button panel including 15 internal button panels had been analyzed to check the accuracy of proposed method and table 2 shows the result of 10 input images of elevator button panels and the ability of the button detection and recognition.

Table 2: Result of 10 input images of button detection

Image	Number of button (in the image)	Number of button (detected)
1	**2**	**2**
2	**2**	**2**
3	**2**	**2**
4	**2**	**2**
5	**2**	**2**
6	**2**	**2**
7	**4**	**4**
8	**5**	**4**
9	**3**	**3**
10	**2**	**2**

Figure 10 clearly show that 9 over 10 images are successfully detected the real number of buttons in the image while another 1 only detecting 4 buttons out of 5. The button

in image 8 unable to be detected due to the style of image captured which it was uncovered for perfect shapes of the button image and that incomplete button lost during noise eliminations process.

IV. CONCLUSION

This paper has already presented a framework for elevator's external button detection by using some combination of image processing method. This framework has achieved promising results which 43 over 50 images of elevator's external button can be detected successfully. As the results demonstrated, techniques of Sobel operator edge detection and Wiener filter with the help of some morphological process and structuring elements able to removes reflection noise and extract the original shapes of elevator button precisely. Concept of "filling holes" is suitable and makes the next process easier in order to detect the elevator's button. Although it have 7 images out of 50 images tested for elevator external button are failed to detect, it can be improved by capturing image with the synergy camera with the professional style of capturing images. In the near future, we plan to improve the constancy of our method by using more techniques in order to removes reflections and noise on elevator's button panel image for more feature extraction.

ACKNOWLEDGMENT

This research was supported by a grant No.GRS130368 from Institute of Postgraduate Studies, Universiti Malaysia Pahang. The data presented, result gained and statement made are solely responsibly by the authors and had been discuss with the members of Robotics and Unmanned System's group from Universiti Malaysia Pahang.

REFERENCES

[1] J. Biswas, "WiFi Localization and Navigation for Autonomous Indoor Mobile Robots," pp. 4379–4384, 2010.

[2] D. Santosh, S. Achar, and C. V. Jawahar, "Autonomous image-based exploration for mobile robot navigation," *2008 IEEE Int. Conf. Robot. Autom.*, pp. 2717–2722, May 2008.

[3] G. N. Desouza and a. C. Kak, "Vision for mobile robot navigation: a survey," *IEEE Trans. Pattern Anal. Mach. Intell.*, vol. 24, no. 2, pp. 237–267, 2002.

[4] M. R. Daud and K. Nonami, "Autonomous Walking over Obstacles by Means of LRF for Hexapod Robot COMET-IV," pp. 55–63, 2011.

[5] C. Shi, Y. Wang, and J. Yang, "A local obstacle avoidance method for mobile robots in partially known environment," *Rob. Auton. Syst.*, vol. 58, no. 5, pp. 425–434, May 2010.

[6] I. Conference, "Navigation Strategy for the Service Robot in the Elevator Environment Jeong-Gwan Kang, Su-Yong An, and Se-Young Oh," pp. 1092–1097, 2007.

[7] X. Yu, "Lift-button detection and recognition for service robot in buildings," *2009 16th IEEE Int. Conf. Image Process.*, pp. 313–316, Nov. 2009.

[8] R. Sim and G. Dudek, "Learning and evaluating visual features for pose estimation," *Proc. Seventh IEEE Int. Conf. Comput. Vis.*, pp. 1217–1222 vol.2, 1999.

[9] H.-H. Kim, D.-J. Kim, and K.-H. Park, "Robust Elevator Button Recognition in the Presence of Partial Occlusion and Clutter by Specular Reflections," *IEEE Trans. Ind. Electron.*, vol. 59, no. 3, pp. 1597–1611, Mar. 2012.

[10] J. Baek and M. Lee, "A Study on Detecting Elevator Entrance door using Stereo Vision in Multi Floor Environment," pp. 1370–1373, 2009.

[11] J. Miura, K. Iwase, and Y. Shirai, "Interactive Teaching of a Mobile Robot," no. April, pp. 78–83, 2005.

[12] W. Wang, C. Huang, I. Lai, and H. Chen, "A robot arm for pushing elevator buttons," pp. 1844–1848, 2010.

[13] E. Klingbeil, B. Carpenter, O. Russakovsky, and A. Y. Ng, "Autonomous operation of novel elevators for robot navigation," *2010 IEEE Int. Conf. Robot. Autom.*, pp. 751–758, May 2010.

[14] K. Ogawa, Y. Ito, and K. Nakano, "Efficient Canny Edge Detection Using a GPU," *2010 First Int. Conf. Netw. Comput.*, pp. 279–280, Nov.