Indonesian Journal of Electrical Engineering and Computer Science
Vol. 7, No. 2, August 2017, pp. 524 ~ 532
DOI: 10.11591/ijeecs.v7.i2.pp524-532

Sign Detection Vision Based Mobile Robot Platform

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Abstract

Vision system applied in electrical power generated mobile robot to provide a comfortable ride while providing comfort to tourist to interact with visitors. The camera is placed in front of the mobile robot to snap the images along in pathways. The system can recognized the sign which are right, left and up by using Harris corner algorithms and will be display in Graphical User Interface (GUI). A sign can be determined from the vertex coordinates according to the degree to distinguish the direction of the sign. The system will be tested in term of percentage of success in Harris point detection and availability to detect sign with different range. The result show the even though not all Harris point in an image can be detected but most of the images possible to recognise it sign direction.

Keywords: *Harris corner, sign detection, mobile robot, graphical user interface (GUI)*

1. Introduction

Usually at the theme park and botanical garden have a mini car or familiar with name buggy car. It uses to carry the passenger to drive at specific area. In our country, most of buggies use the normal engine which provides air pollution. The electrical buggies will be more practical for eco-environment. In order to achieve this, the high technology system can be integrated inside such as vision system as a feedback for the car turning. This system can make the driverless ride more safety and friendly especially for the tourism. Based on the situation occurred and several impacts, it is motivated to create a vision system that will be test at mobile robot before applied to the buggies.

The buggy car at the theme park need to move automatically for the tourist guide to explain clearly about the landscape or something related with less risk. While explaining, the tourist guides need to focus on what they need to say and also while driving. Therefore, a vision system need to be created for the mobile robot replace a buggies where it can move or turn based on sign from the side of the road. It will be more safety. To apply vision system, a small camera will be placed at front of the mobile robot and the system will decide the movement direction of mobile robot according to sign. The environment must be considered to be at daylight condition.

In this paper we develop and implement the sign detection algorithms for mobile robot platform. The study was based on arrow sign consists of up, left and right conditions. The parameters will be extracted using Harris Corner point detector with eigenvalues decompositions. Then we test and analyse the performance of sign detection algorithm decision according to the correct sign direction.

2. Literature Review

A vision based system is a computer based system that accepts visual inputs and does the specific action. The image will be process and the system will decide the next action based on content of the image. It is an interactive devices and habitual sense where human can receive interaction from others. Besides that, it is also contactless that never impose additional weight on user [1].

Received May 11, 2017; Revised July 5, 2017; Accepted July 23, 2017

There are advantages of applying vision based via single camera such as it can avoid the problems of matching image features between different views [1-3]. While in 2D image capture, it is most suitable to be applied. It can also make the processing faster than stereo vision that needs a lot of step on determining it. Besides of using this single camera, it also has disadvantage. If the system needs to recognize the 3D object or need to avoid the obstacles, it must be support by 2 cameras or using ultrasonic sensor. It depends on how the system is applied for most suitable cases. To get the range for a single camera is by using perspective. One of it is determine by size of the image [4].

The main of stereo vision systems is to implement human's visual function. The input image information must be detected or recognize [5]. For 3D shape detection, this stereo vision mostly use since it is the most suitable. There is a few of advantages that is capable of obtaining exact and wide range of the distance information [6-9]. Meanwhile, the disadvantages is occur when to implement it such as, stereo correspond method, real-time performance of stereo vision systems, and hardware implementation [10]. In the certain object is located on the corner of the image plane in the stereo vision system where the camera is fixed, the error occur due to lens distortion, it can affect the reliability. There can be encountered back when cross stereo vision system always places the object in the middle of image. Then the lens distortion can be less and increase the reliability.

Omni vision has been use in many fields since the vision is wider for example by using fisheye lens [11]. The advantages of using this camera is it has wide vision up to 185 degree of angle which the normal vision cannot see [12] while it also has a dead angle [13]. Besides that, the image captured has more distortion. The position in an image cannot be taken directly but it needs to be calibrated by the optical centre of the fisheye lens.

Table 1. Comparison between the vision using camera

Vision-based using camera	Advantage	Disadvantage
Single camera [25]	Efficient for detecting a 2 dimension image	Cannot detect for 3 dimension object
Stereo vision	More accurate while detect a 3 dimension object	Stereo correspond method, real time performance and hard to implement the hardware
Omni vision	Vision is wider than stereo vision up to 185 degree	Has a blind angle and image captured more distortion

Each of the vision has their own advantages and disadvantages. From the criteria for each vision, single camera is the most suitable since we only require it to detect a sign which is in 2 dimensions. The processing time is much faster than stereo vision that requires more steps. Meanwhile, for Omni vision does need to calibrate to avoid the distortion. Tables 1 show the comparison between visions using camera.

In the sign detection, it has many ways in order to obtain sign based on what kind of sign that we want to detect. It is including by image capturing and capture a color image of a sign which calculates a feature value of each pixel corresponds to the color of sign. Nowadays a car using high technology to improve their safety while driving to recognize and detect sign traffic in a road. Besides of having a dashboard camera to record traffic incident, it can use for another purpose that is traffic sign detection. A color-based segmentation method is used to scan the scene in order to quickly establish region of interest (ROI) [14-19]. There are commonly 3 steps which are the color based segmentation stage, the detection of the interest region and the shape recognition of the road sign stage.

In order to use geometric structure analysis, each sign must be categorized in the same group. Color and shape properties of sign are used to locate the sign region. The connected region will be label and will reduce the number of sign. Then the sign is created into it categorize before shape analysis, extracting meaning part and template matching [20-24].

3. Methodology

3.1. Image Filtering

Filtering [26-29] is used for blurring or reducing noise in an image. In blurring, pre-processing process we apply removal of small details from an image prior to object extraction and bridging of small gaps in lines or curves. Then by blurring the images with a linear filter and nonlinear filter is applied to reduce the noise.

3.2. Region of Interest (ROI)

Region Of Interest (ROI) is defined by creating a binary mask, which is a binary image is the same size as the image to process with pixel that define the region set to 1 meanwhile outside the region is set to 0.The ROI is represented as bwlabel. It contains label for the connected object in Black & White. The input dimension is 2-D and has connectivity of 8. Figure 2 show the red box region is called as ROI.

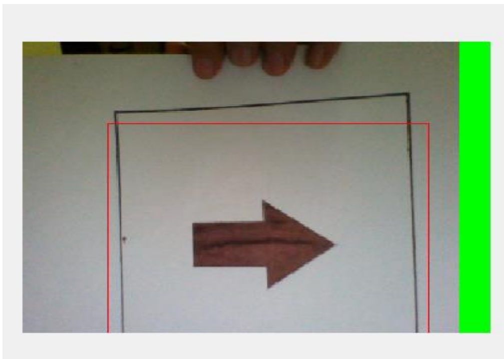

Figure 2. Region of Interest Representation

3.3. Harris Corner Detection

Harris corner is used to obtain the corner pixels coordinated will be appears at x-axis and y-axis gradient [30, 31]. Figure 3 shows large amount of pixels are detect at both gradient.

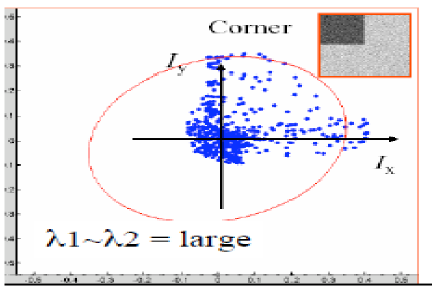

Figure 3. Pixels detection at both gradients

The eigenvalues is determined by using eigenvalues decomposition obtain from the large amount of pixels detected at both gradient by using the Equation 1 and 2 where k is an empirically constant between k = 0.04 to 0.06. Figure 4 shows the Harris corner detected in white box in an arrow sign.

$$C = \begin{pmatrix} \sum I_x^2 & \sum I_x I_y \\ \sum I_x I_y & \sum I_y^2 \end{pmatrix} \tag{1}$$

$$R = DET(C) - k(Trace(C))^2 \tag{2}$$

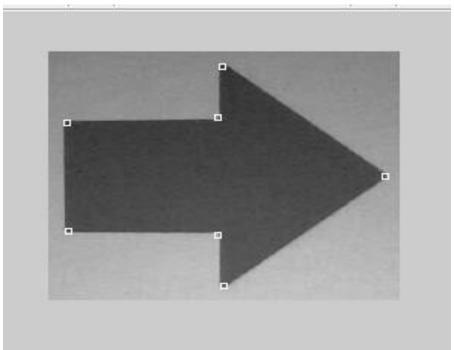

Figure 4. Harris corner detected results in an arrow sign

3.4. Obtain Angle from Arrow Image

The coordinate is acquired from Harris corner, it will be used to another purpose which is to find the angle from the arrow. From this coordinated, a geometry theory in standard math can be used to apply to determine the angle of three points. Figure 5 show the example of geometry approaches.

```
x1=0;x2=4;x3=4;
y1=0;y2=0;y3=3;

a = sqrt((x2-x3)^2+(y2-y3)^2); % The three sides
b = sqrt((x3-x1)^2+(y3-y1)^2);
c = sqrt((x1-x2)^2+(y1-y2)^2);
angleA = 2*atan(sqrt((a+b-c)*(a-b+c)/(a+b+c)/(-a+b+c))); % Angle BAC
```

Figure 5. Coding for angle detection

The camera will be attached on the mobile robot platform which can be control by a wired controller. While the robot is moving, the camera will be captured the image. Figure 6 and Figure 7 shows the wireless camera mounted on mobile robot platform at second base and zoom in image of camera position on mobile robot respectively.

Figure 6. Wireless camera mounted on mobile robot platform

Figure 7. Camera position on mobile robot

3.5. Graphical User Interface (GUI)

Graphical User Interface or familiarize with GUI is used to indicate or to give the view while the program is executed. The movement for the robot can be monitored from the first right axes after image acquisition button is pressed. The left axes in GUI will indicate the image after ROI is detected. In middle axes show the B&W image and the arrow direction. Figure 8 shows the Graphical User Interface (GUI) screen function while Figure 9 shows the Graphical User Interface (GUI) during the programme is executed.

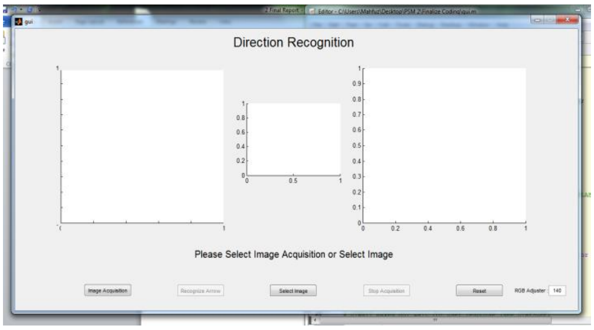

Figure 8. Graphical User Interface (GUI) screen function

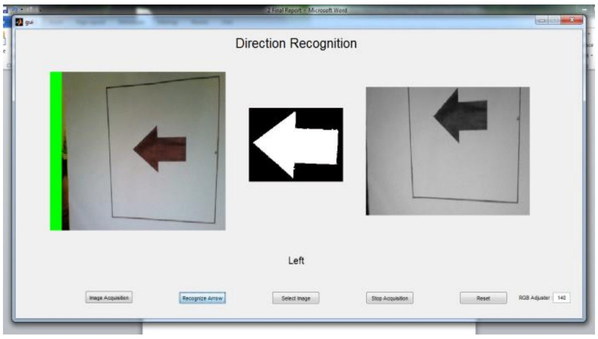

Figure 9. Graphical User Interface (GUI) during programme is executed

4. Results and Discussion

4.1. Experimental Setup

The experiment is setup by attach the camera on mobile robot. Then, sign is put at left side on mobile robot pathway. Next step will be followed by each different experiment.

4.2. Test 1: Percentage of Success for Harris Point Detected

In order to get the percentage of success, a lot of samples need to be taken to evaluate the percentage of successful for sign detection. First of all, the position and distance between camera and image are fixed. Each sign are taken 9 times and total would be 27. The sample is assumed as success if there is all 7 point detected. The calculation is as follow:

% Percentage for 1 sample = N/7 x 100%

Where N is a number of points detected

Table 2. Percentage of success for right arrow

Sample	1	2	3	4	5	6	7	8	9
Percentage (%)	100.0	42.9	100.0	100.0	100.0	100.0	100.0	28.6	100.0

Table 3. Percentage of success for left arrow

Sample	1	2	3	4	5	6	7	8	9
Percentage (%)	100.0	100.0	28.6	71.4	28.6	85.7	28.6	100.0	85.7

Table 4. Percentage of success for up arrow

Sample	1	2	3	4	5	6	7	8	9
Percentage (%)	100.0	42.9	100.0	100.0	100.0	100.0	28.6	100.0	100.0

The samples of arrow are taken for each direction of it. To determine the successful of Harris corner each images need to determine with different orientation. For this image, Harris point should be total 7 for 100% successful. Figure 10-12 shows the sample taken for right, left and up arrow respectively.

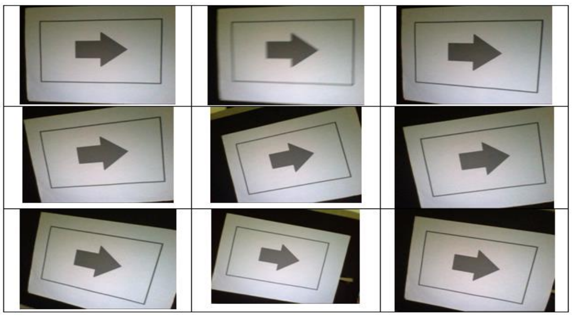

Figure 10. Samples taken for right arrow

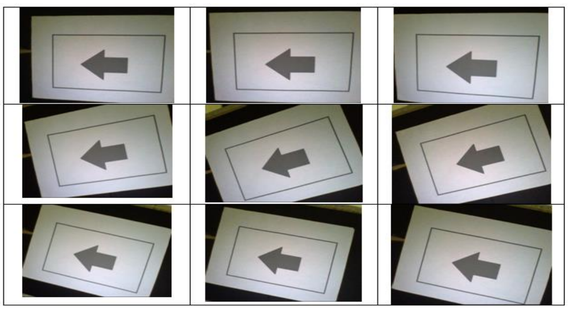

Figure 11. Samples taken for left arrow

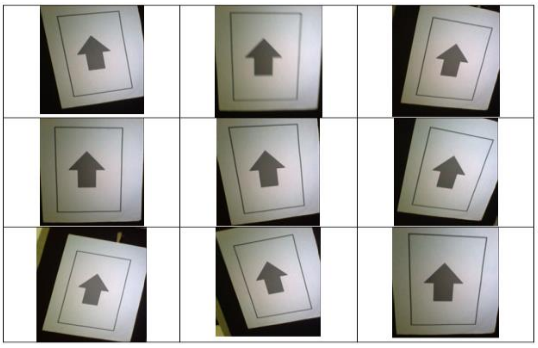

Figure 12. Samples taken for up arrow

From the results, not all sample images can be successfully detected the corner. Some of the arrow placed exactly at the middle of ROI and thus make it more perfect. Based on Figure 10 it about 7 samples is successes detected and another 2 did not. Figure 11 gives only 3 samples success but for others image still can be detected. Meanwhile Figure 12 shows 7 samples success detected.

4.3. Test 2: Availability to Detect Sign with Different Range

In this test, the range between sign and camera is determined by trial and error variables. This test needs to verify because range is important to determine the precision of sign detection algorithm. The height of camera and sign is fixed. Camera will move backward by 10cm for each reading until reach 100cm a far from the sign.

Table 5. Availability for sign detected in different range

Range (x10cm)	1	2	3	4	5	6	7	8	9	10
Availability	No	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No

The range is set by 10cm different and as long as the sign can be detected. The result shows the range can be used within the area 30cm - 80cm far from image. This is because if the image is taken too near, the system cannot detect the first condition which is 15cm square box.

4.4. Test 3: Applications of GUI for Direction Recognition

The system will detect the different arrow and will be display the recognition image results and decision made by it at Graphical User Interface (GUI). Both offline and online mode can be carried out from the same GUI.

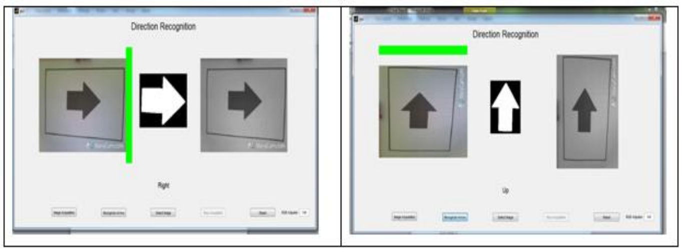

Figure 13. Offline mode image detection select by image button

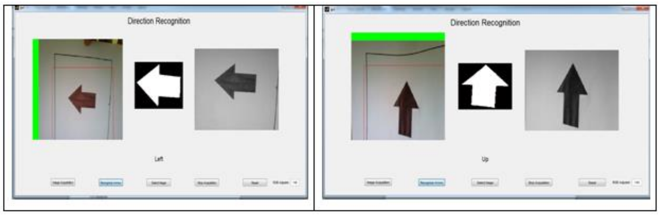

Figure 14. Online mode image detection image acquisition button

In offline mode, decision making results can be display on GUI with the correct recognition for both right and up image. 'Select Image' pushbutton used to call the image obtained by capture it in '.jpg' format. The static image is easier to process rather than online mode that image is taken from video input. Meanwhile, for online mode, decisions made are correct for each direction by 'Image Acquisition' pushbutton. 'Stop Acquisition' and 'Reset' pushbutton are used to stop the image obtain from camera and to reset all the data taken from previous process respectively.

5. Conclusion

As a conclusion, even though not all Harris point in an image can be detected, most of the images success to recognition a direction of sign. To solve this problem, we set the image in centre because region of interest set is at the centre region within the box. The color for sign and background must be in clear weather totally black or white.

For Further works, besides using the angle for differentiates between the arrows a coordinate position can be apply. However, the result can be improved if the centre region of interest is widened. This is important because the image taken not necessarily well captured. Therefore the bigger area can perform more chance to sign recognition success.

Acknowledgement

The authors also would like to thank Ministry of Education Malaysia (MOE) and Center for Robotics and Industrial Automation, Faculty of Electrical Engineering, Universiti Teknikal Malaysia Melaka (UTeM) for the financial assistance.

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