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Template Mask based Parking Car Slots Detection in Aerial Images

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Abstract

The increase in vehicle purchases worldwide is having a very significant impact on the availability of parking spaces. In particular, since it is difficult to secure a parking space in an urban area, it may be of great help to the driver to check vehicle parking information in advance. However, the current parking lot information is still operated semi-manually, such as notifications. Therefore, in this study, we propose a system for detecting a parking space using a relatively simple image processing method based on an image taken from the sky and evaluate its performance. The proposed method first converts the captured RGB image into a black-and-white binary image. This is to simplify the calculation for detection using discrete information. Next, a morphological operation is applied to increase the clarity of the binary image, and a template mask in the form of a bounding box indicating a parking space is applied to check the parking state. Twelve image samples and 2181 total of test, were used for the experiment, and a threshold of 40% was used to detect each parking space. The experimental results showed that information on the availability of parking spaces for parking users was provided with an accuracy of 95%. Although the number of experimental images is somewhat insufficient to address the generality of accuracy, it is possible to confirm the possibility of parking space detection with a simple image processing method.

Keywords : Detection, Morphological Operation, Bounding Box, Parking Slot

Ⅰ. Introduction

The increasing number of vehicle purchases has an impact on the amount of vehicle production, which continues to this day. Of course, with increasingly sophisticated vehicle technology, especially in cars, there is less space to park the car properly and safely. The number of vehicles occupying a parking space in a location or area is often uncertain and does not directly indicate the condition of the

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parking lot, whether it is filled or not. This affects whether or not it is easy to find a parking space. And of course, this problem causes car drivers to turn around to look for available parking spaces and lose a lot of time, especially if the parking lot is very large, such as at airports, malls, stadiums, and others[1].

Currently, parking lot monitoring is still classified as semi-manual, meaning someone is still needed to point out the direction of an empty parking lot. However, some parking lots are equipped with technology, such as installing lights that indicate whether they are occupied or not[2]. With manual monitoring, problems often arise when motorists jostle for a parking space, but quite a few also fail to get a parking space, resulting in parking violators clogging the streets and disrupting operations. With image processing technology that can help directly monitor the parking lot, drivers will later find and know the available spaces for parking[3].

Several studies have applied image recognition methods to detect parking lot objects. Among them are the convolutional neural network (CNN) and the blob circle detection method[4]. In research conducted by Tatuela and friends[4], they have succeeded in detecting parking slots using the feature-based method with an accuracy of 93% of the resulting data. In this study, we tried to build on research that had been done previously by Tatuela and friends using different methods. In this study, we used a simple method that has good ability for detecting parking lots. The aerial image that has been taken is transformed into binary form. This transformation process changes the initial composition of the RGB image to binary by changing the pixel values into two types of information, namely 0 and 1. The pixel values that represent information will be transformed to a value of 0, and those that are not part of the information will be given a value of 1. Then, with this method, the image is classified based on the template mask on the bounding box, where the bounding box functions as a detector of information taken from the object, so using this method makes it easier to detect the information contained in it. For example, if the vehicle enters the bundling box in more than 40% of the parking slots, then the parking space will be filled and given a True Negative (TN) value with the X sign. If the vehicle does not enter the bounding box or is not within the specified threshold, it will be detected with a green O sign, which indicates there is still something we call True Positive (TP). The purpose of this study is to automatically detect and determine the status of parking availability with aerial image.

The bounding box is a rectangle that serves to detect the predefined template mask when the conversion process to binary and morphological is complete. The purpose of the bounding box itself is to display the results of detecting parking spaces that are available or not, in addition to identifying positions and information during image processing. There are several types of bounding boxes, some of which are based on the top and the bottom right point of an object that we usually see in the approach detection using YOLO, and in this study the bounding box used is based on the width and height of an object in aerial images.

Ⅱ. Proposed Method

The proposed system is intended to identify vacant or occupied spaces in available parking lots so that they can be better organized. The system created is able to recognize the vehicle in the parking slot automatically and can tell whether the slot is empty or not. The system is able to recognize a car when part of the car enters the masking template that has been placed in each parking slot. With a threshold value of 40%, it will anticipate false occupancy.

Figure 1 shows a block diagram of the system design in this study. The proposed system is able to identify empty slots and fill them properly. In the early stages, the RGB image (Red, Green, and Blue), which has 3 color channels, will be converted into grayscale form. This aims to change

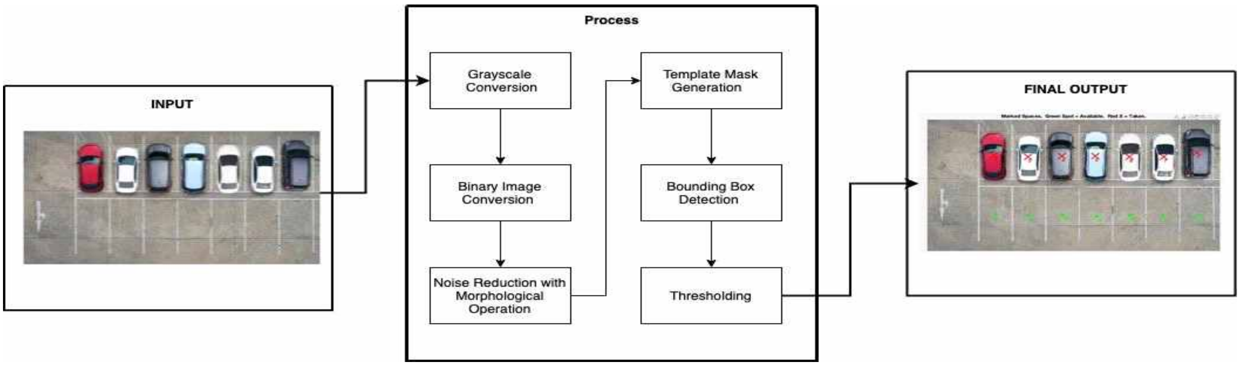


Fig. 1. Block Diagram of Detection System

the color value in it to 1 color channel in degrees of gray. After that, the image will be converted into binary form to separate the desired information and make it easier to detect in the system. This process also utilizes morphological operations to reduce the amount of noise generated in the binary image after entering the detection process. The method used to detect parking slots is Bounding Box Detection[1]. This method has the advantage of recognizing information that enters the bounding box and can identify it based on a predetermined number of thresholds. If the vehicle enters the parking slot more than 40% of the width and length of the guardrail, it will be considered a vehicle, otherwise it will not be detected as a vehicle[5][6]. This study will utilize a rectangular parking lot and bounding box to assist in detecting the status of each existing parking slot. The image used in this research is aerial imagery. The image resolution used is 1080 x 720.

1. Aerial Parking Slot Sampling (Input)

The initial image we chose was of a fairly crowded parking lot with vehicles, as shown in Figure 2. The image we used is an aerial image of an active parking lot with many

Table 1. Parking slot test sampling results

Sample Image	Number of Slot Sample	Number of parking
Test 1	217	82
Test 2	90	60
Test 3	92	40
Test 4	118	41
Test 5	125	58
Test 6	233	93
Test 7	98	67
Test 8	156	96
Test 9	217	120
Test 10	360	270
Test 11	140	90
Tes 12	225	145

Fig. 2 Image Sampling Test 1

vehicles. The image is composed of as many as six sample images that are in different places. Table 1 shows the number of parking slot samples from each photo taken and the number of parked vehicles. Our goal is to use busy parking lots to determine the accuracy of the system we have built in actively detecting parking spaces.

2. Grayscale Conversion

The initial image conversion into a grayscale image aims to separate the RGB color channel into 1 channel or gray level, so that only values with intensity levels of gray are displayed. Because grayscale images only have 1 channel, only a little information can be obtained from each pixel so that it does not burden memory very much when com-pared to color images such as RGB, as shown in Figure 3. The intensity of the grayscale image is stored in 8 bits. An integer that gives 256 possibilities which start from level 0 to 255 (-for black and 255 for white, and between them are colors with degrees of gray) The level of gray or grayscale level.

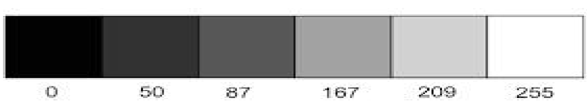


Fig. 3. Grayscale level

Fig. 4. Grayscale Conversion

As seen from Figure 4, the results of the experiment, the image that originally had the RGB color (Red, Green, Blue) turned into a grayscale image or an image with a degree of gray. The process used to obtain a grayscale image is done by finding the average value of the total RGB values.

3. Binary Image Conversion

The results of the grayscale image will be converted back into the form of a binary image or black and white image. This is done to separate the information into more specific (black and white) and no other colors. We convert to binary so that the value of the information we want to retrieve becomes more detailed so that when applying template masking generation it will reduce errors during

Fig. 5. Binary Conversion

detection. Grayscale images only focus on the degree of gray in an image, meaning that the displayed image has different color gradations. Whereas with a binary image, as shown in Figure 5, a binary image only has two possible colors, namely black and white, there is no other color possibility. A binary image only has two values, namely 0 for white values and 1 for black values. So, in a binary image, the background is white while the object is black.

To get a binary image, we need an image that has been converted into gray scale, and the next process is thresholding, or the specified threshold value. If the pixel value in the grayscale image exceeds the threshold value, then the pixel value is converted to 1. If the pixel value is less than the threshold value, then the pixel value will be converted to 0. In theory, it can be written as follows equation 1.

$$g(x,y) = \begin{cases} 1, if\ \ f(x,y) \geq T \\ 0, if\ f(x,y) < T \end{cases} \tag{1}$$

where :

- $f:(x,y)\ grayscale\ image$
- $g:(x,y)\ binary\ image$
- T: $threshold$

4. Noise Reduction with Morphological Operation

As seen in Figure 5, binary results obtained from the conversion of grayscale images have very high noise. Therefore, minimizing noise must be done so that errors do not occur during detection. In this study, we use morphological operations as a way to minimize noise so that the resulting image can be clearer and minimize detection errors. The core of this operation or calculation involves two types of pixels: the first is a binary image to be processed by morphological operations, and the second is the kernel or structuring element[7]. In the example shown in Figure 6, the central pixel is called a hotspot and is marked with a grayscale color. This center pixel is the center when performing operations on the image.

The morphological operation process itself is that each pixel value in the original image is then converted into binary form, as shown in Figure 7. where the value 1 represents information on the image while the value 0 is not part of the information. This pixel limit value will be detected by a mask of the information contained in it.

Two operations that underlie morphology are dilation

0	1	0
1	1	1
0	1	0

1	1	1	1	1

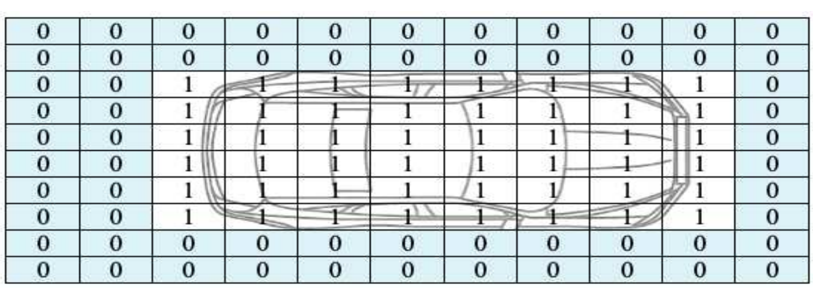
1	1	1
1	1	1
1	1	1

1	1	1	1

1	1
1	1

1
1
1
1
1

Fig. 6. Example of the Kernel



0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	1	1	1	1	1	1	1	1	0
0	0	1	1	1	1	1	1	1	1	0
0	0	1	1	1	1	1	1	1	1	0
0	0	1	1	1	1	1	1	1	1	0
0	0	1	1	1	1	1	1	1	1	0
0	0	1	1	1	1	1	1	1	1	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0

Fig. 7. Illustration of Kernel Operation on an Aerial Image

and erosion[8]. Two other operations that are very useful in image processing are Opening and closing in forms through these two operations. Sequentially, the equations used for each operation are:

$$A \oplus B \quad (2)$$

$$A \ominus B \quad (3)$$

$$A \bullet B = (A \oplus B) \ominus B \quad (4)$$

$$A \circ B = (A \ominus B) \oplus B \quad (5)$$

4.1 image. B: structuring element (operator matrix is rectangular)

The results of the morphological operations performed in Figure 8 It can be seen that the amount of noise produced can be minimized when compared to the previous one, so that the information value of the existing parking slot is not lost and it is easier to detect. If we look from a different point of view at this morphological operation, in figure 9 it can be seen that the amount of information about parked vehicles will be selected and can be more easily detected from the color produced, and those without

Fig. 8. Morphological Operation Results

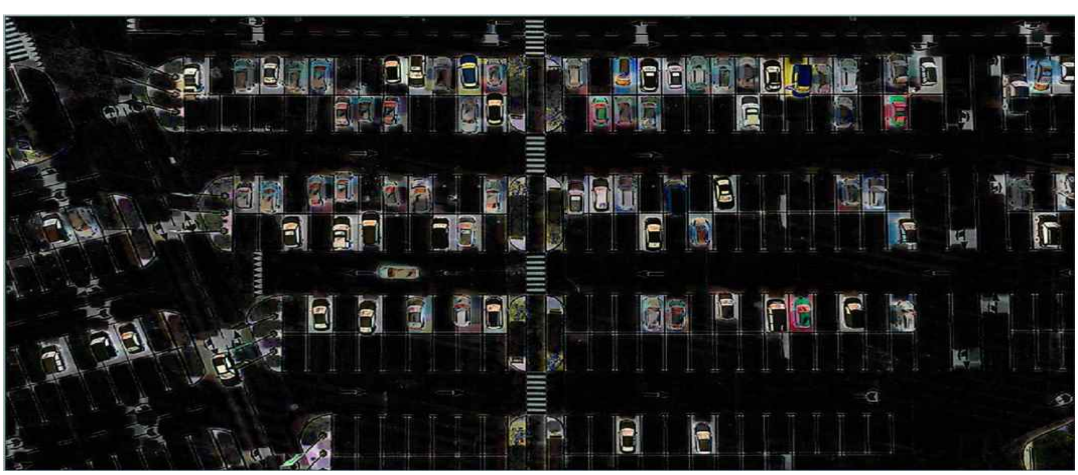


Fig. 9. The results of morphological operations from a different point of view

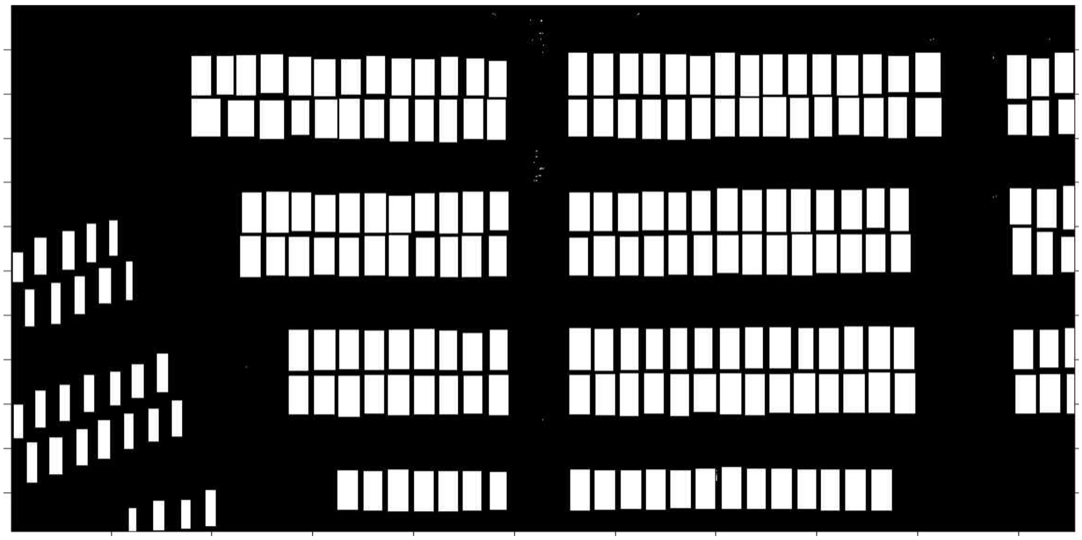


Fig. 10. Template Mask Generation

vehicles will be black or dark, which means there is no information inside them. The results of experiments on this morphological operation will be the key to making template mask generation at the detection stage.

5. Template Mask Generation

After the information value of the image is obtained, the next step is to create a mask template, as shown in Figure 10. The mask template is created by giving a white1 rectangular that is applied to all parking slots that have been determined according to equation (2). This technique is intended so that when detecting using a bounding box, the bounding box will focus more on the template mask, which contains vehicle information that is in the structuring element, thereby minimizing the cost of time required to scan each part of the image. The detection process starts from the top left corner of the template mask, which is marked with x1 and y1, and ends at x2 and y2. If the information is only entered by 40%, it will be considered "occupied. X" but if it is below 40%, it is considered "not occupied. O" In the next section, explain in detail what is meant by a bounding box.

6. Bounding Box Detection

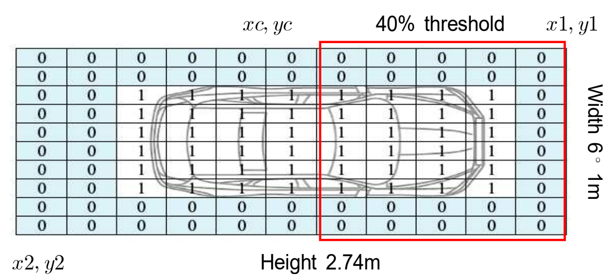


Fig. 11. Bounding Box Parking Dimension

Parameters used to define a bounding box:

- Class: Information inside the box
- $(x1,y1)$: The x and y coordinate of the rectangle's top left corner.
- $(x2,y2)$: The x and y coordinate of the bottom right corner of the rectangle.
- (xc,yc): The x and y coordinate of the center of the bounding box.
- $Width$: Represents the width of the bounding box.
- $Height$: This represents the height of the bounding box.
- $Confidence$: Indicates the limit of the object's possibilities within that boundary. 0.4 is a limit threshold

that is allowed or about 40% of the object information is in the box.

Converting between the conventions:

The converted form is a shape that represents a bounding box, in this study we use it to detect the presence of a large object, namely a car as shown in Figure 11.

$$xc = \frac{x1 + x2}{2} \tag{6}$$

$$yc = \frac{y1 + y2}{2} \tag{7}$$

$$width = (x2 - x1) \tag{8}$$

$$heitht = (y2 - y1) \tag{9}$$

At this stage, the information that has been selected in the morphological operation will be detected by adding it using a bounding box. This detection process ensures that the value will be focused only where the template mask has been created. Figure 12 shows the result of separating information based on a predetermined mask. In Figure 12, the quality of the information cannot be well determined by knowing whether it meets the requirements or not. Therefore, in Figure 13, we use a bounding box to be able to detect the quality of the information obtained with a predetermined standard.

Ⅲ. Experimental Result

1. Thresholding

The final step is to detect the parking slots that are filled

Fig. 12. Information Screening

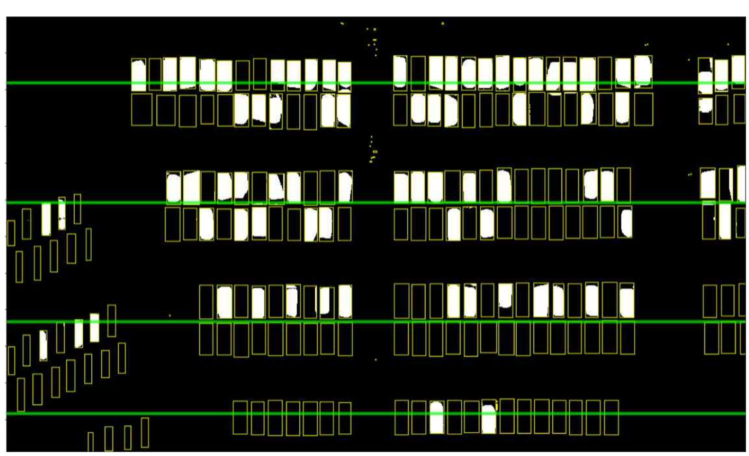


Fig. 13. Bounding Box Detection

or empty by using a bounding box. This bounding box will adjust the template mask that was set in the previous process. The threshold that we set in this method is 40%. This value was chosen because it has a stable value when the parking lot is filled with vehicles. The 40% threshold value is determined based on the input data that we use using aerial images. The detected vehicle must enter the template mask by as much as 40% of the template mask width. After that, the information from the method used will give the result that the parking slot is filled. If it is below 40%, it will not be detected by the mask, so it is concluded that it is not information from the vehicle. If the threshold value is reduced to 20%, the information captured is not in accordance with the wishes of the researcher. This results in incorrect information that will be taken in detection using this approach. The error detects objects such as standing people, bicycles, and so on that have a threshold below 40%[9][10].

The results of the detection performed are displayed. The success rate in detection with the number of test samples is 12 and the total number of tests is 2181 in table 2. From these results, it shows an accuracy rate of 95%. When compared with previous studies, this value is much better with an increase in accuracy of 2%in table 3. The test results from this study are divided based on 4 different categories, including: TP (true positive) indicating the success of the test detection with a occupied parking slot; TN (true negative) indicating successful detection but no vehicle in the parking slot (no occupied); FP (false positive) indicating's a failure to detect parking slots according to the template mask that has been create, this condition is because the vehicle parking conditions are not suitable or the parking slot is too narrow, as seen in Figure 14 and 15, the FN (false negative) indicating's a failure to recognize the mask (the example considers a zebra cross or path line as a mask).

Fig. 14. False positive (X) & false Negative (O)

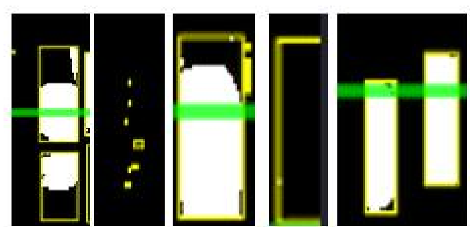


Fig. 15. .Thresholding result of false detection

Table 2. Detailed Results of Sample Test

Sample Image	TP (True Positive) Occupied	TN (True Negative) Not occupied	FP (False Positive)	FN (False Negative)	(TT) Total Testing
Test 1	82	135	5	8	230
Test 2	60	30	2	1	93
Test 3	40	52	2	0	94
Test 4	41	77	6	8	132
Test 5	58	67	2	7	134
Test 6	93	140	3	5	241
Test 7	67	31	5	8	111
Test 8	96	60	4	8	168
Test 9	120	97	4	6	227
Test 10	270	90	7	5	372
Test 11	90	50	4	2	146
Tes 12	145	80	5	3	233
Total	1162	909	49	61	2181

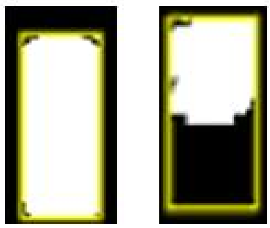


Fig. 16. Comparing Good Threshold and Bad Threshold

Figure 16 shows the comparison between thresholding that is detected well by the bounding box and that which is not detected by the bounding box[12]. It should be noted that the failure in question is more appropriate when it cannot distinguish the mask from the road line or zebra cross, so the test results will immediately conclude according to the accepted conditions based on the 40% threshold. In addition, during the conversion process to a binary image, there are some pixels that are not perfect in the transformation, leaving traces of small dots in certain parts. This will lead to misunderstandings in detection, as we can see in Figure 15. Overall, the results of the tests that have been carried out show that using this method can detect parking slots well even though there are still errors, but it does not have a significant effect on overall results and is still within reasonable limits.

2. Results

The results of the detection of parking slots that have been carried out show that the system has succeeded in detecting parking slots with an average accuracy rate of 95%, where 2% is better than before. The values obtained are: TP 53.3, TN 41.7, FP 2.2, FN 2.8, Precision 96%, Recall 95%, and Overall Accuracy rate 95%. From these results, a significant comparison of all aspects tested was obtained when compared with previous studies. This system is able to help driver find out information about the parking slot directly by looking at the results of the images obtained, so that driver no longer scramble to get a parking space and waste time looking for an existing parking space. The

Table 3. Results Accuracy Rate

	Proposed
Total number of Tested	2181
TP	53.3
TN	41.7
FP	2.2
FN	2.8
Precision = TP/TP+FP*100	96.0
Recall = TP/TP+FN*100	95.0
Accuracy = TP+TN/TP+TN+FP+FN*100%	95%

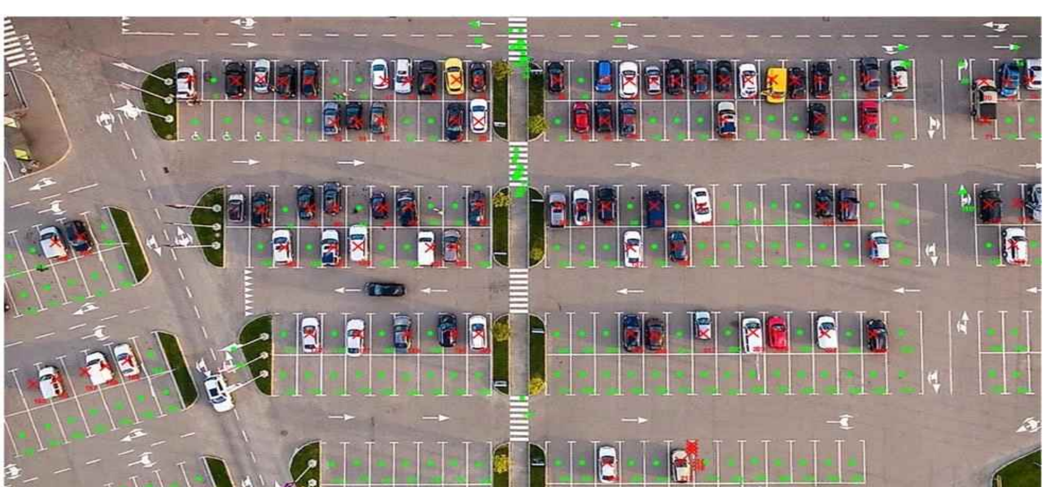


Fig. 17. Detection Results Parking Slot Sample Test 1

system that we created is able to adapt to changes in existing information as long as the sample image does not change[5].

Ⅳ. Conclusion

This study develops a system to identify the availability of parking slots in open spaces using image processing methods, especially morphological operations. By utilizing detection using this method, it is possible to detect the availability of parking slots correctly. By converting the initial information to binary, it will be easier to separate the desired information and improve the detection quality because the image will only consist of 2 color channels. The successful identification of 12 sample test images and 2181 total number of test shows an average accuracy rate of 95%. This system is able to help driver find out information about the parking slot directly by looking at the results of the images obtained, so that driver no longer scramble to get a parking space and waste time looking for an existing parking space. The system that we created is able to adapt to changes in existing information as long as the sample image does not change.

The current detection technique is still very basic but can be improved in the future by scaling up the existing parking slot data set and being able to detect indoor parking. The results can be optimized better by developing the mask structure to improve the performance of the detection. In addition, the study can be expanded to assess whether the parking slot is occupied or not by combining sensor and obstacle detection based on a convolutional neural network.

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