Perspective Transformation Automation in Identification of Parking Lot Status with Blob Detection

Mohammad Nasrul Mubin
Electrical Engineering
Universitas Muhammadiyah Surakarta
Surakarta, Indonesia
nasrul.mubin@ums.ac.id

Hendra Kusuma
Electrical Engineering
Institut Teknologi Sepuluh Nopember
Surabaya, Indonesia
hendraks@ee.its.ac.id

Muhammad Rivai
Electrical Engineering
Institut Teknologi Sepuluh Nopember
Surabaya, Indonesia
muhammad_rivai@ee.its.ac.id

***Abstract*—Implementation of automation greatly facilitates the work of a system. This research automates the search for perspective transformation coordinates. In previous study, the process was done manually and was considered time-consuming and costly. The search for these coordinates is carried out with the help of red circles at several points in the parking area to be identified. There are two cases of images to be automated, namely the image of the parking area without obstacles and with obstacles. In the unobstructed images, the identification of transformation coordinates is carried out by identifying the coordinates of the auxiliary circle. Whereas in the images with obstructions, the identification of the transformation coordinates also involves the intersection equations of lines. The process of identifying the coordinates is done with the condition of the parking lot without a single vehicle. Once the coordinates are obtained, all coordinates are stored and will be used in the perspective transformation process in status parking slot identification stage. The identification stage is same with previous study. The proposed system 100% able to identify the transformation coordinates and carry out the perspective transformation process as expected. Of the 900 samples in each case, we acquire 100% recall, and most of the parking slot identification status being above 85% precision and accuracy. Compared to previous studies, the proposed system is more effective, with recall, precision, and accuracy values at 100%. The effectiveness of the proposed system is even more evident with average data automation time is 31.689 seconds.**

***Keywords*— automation; circle blob detection; image processing; parking lot; perspective transformation**

I. Introduction

The increase in human mobility and the number of vehicles as a transportation has not been matched by the availability of parking lots. Today's society requires transportation facilities and infrastructure that are adequate, safe, comfortable, and affordable in daily mobility [1]. In line with this, as the community's economy increases, the number of cars in society increases [2]. However, this is not matched by the availability of parking lots in public areas. This is the background to the study of the effectiveness of the use of available parking lots.

Studies on the effectiveness of the use of parking lots include studies on smart parking systems [3][4], parking reservation system [5], parking lot security system [6], and parking lot detection [7][8]. Until now, studies regarding the identification of parking lot have been carried out using various methods, especially by utilizing remote sensing methods, namely image capture. Remote sensing plays a role in facilitating the analysis of an area without having direct contact with the object under study [9]. Study on parking spot detection using perspective transformation and Hough transform algorithms [10] shows that the detection of parking lots in multi-camera coverage can be identified accurately. However, in this study the emphasis is only on parking slot detection without detecting the empty or the fill status of the slot. The process of determining transformation coordinates in this study is also still manual, which of course has an effect on system operating time and costs. In addition, this study is still in the form of a prototype, not really implemented in the actual parking environment. Another study regarding symbol identification with haar cascade classifier algorithm to monitor parking space vacancies [11] shows that the system is able to give the best results with a total of 108 images and the number of stages is 15. This study was using blue-red circle symbol to detect the parking lot status. However, this study is also still a prototype without real application in parking lots. In addition to these two studies, a parking lot identification study with yellow auxiliary circles [8] showed that the system was able to identify the status of a parking space with a success rate above 99% with 46 image samples. In this study, the system detects each parking slot and identifies the status of the parking slots. The study data shows that there is still room for system development, even though the identification success rate from the study is high, but it has not been shown that the study is resistant to differences in weather, light intensity, or other disturbances. It should be noted that the number of samples used is still relatively small. In addition, the process of determining the transformation coordinates is still done manually. However, compared to the two previous studies, this study has been tested directly in the parking lot.

The identification of related studies [8] utilizes a yellow auxiliary circle in each parking slot. Each auxiliary circle in 6 slots is identified using blob detection algorithm after the images going through HSV color space conversion, histogram equalization, perspective transformation, region of interest for slot images partition, and binarization of each slot image. If a parameterized blob detected in slot image, then the parking slot status is empty, meanwhile if there is no blob in certain slot, the slot is occupied by a vehicle. In previous paragraph, it has been mentioned that one of the weaknesses of this study is the process of determining perspective transformation coordinates which is still manual. This manual process is a problem in itself, because in determining the perspective transformation coordinates it cannot be done carelessly. What may be done in this process manually is by trial and error method. This method definitely requires a lot of time, thus it can also be said that the operational costs incurred are also higher than the more effective methods. One of the more effective methods used nowadays is the automatic method, therefore this study focuses on developing the automatic determination of perspective transformation coordinates.

System automation is believed to improve work quality. However, to find out the long-term benefits of implementing automation, the system must first be designed with a human-centered approach [12]. For this study, the system has been made human-centered in previous studies. This automation is expected to save costs, effort, and time. According to a study, some of the advantages of automation are reduced operator workload, operator attention can be diverted to other tasks, reduced impact of stress factors, reduced fatigue factors, more stable, and eliminated human errors [13].

There are several studies involving perspective transformation. A study in 2019 regarding the automation of position recognition and slab angle rotation in steel plate production was carried out using a perspective transformation algorithm [14]. A study on estimating vehicle speeds in 2021 also use perspective transformation algorithm [15], this study estimate vehicle speeds by transformed the captured images using those algorithm. In the world of sports, perspective transformation is used to determine the real location of soccer players on the field [16]. The perspective transformation algorithm is also used in other studies, such as vehicle detection and tracking [17], document image auto-correction [18], and count object in an image [19]. These studies have shown that perspective transformation can be used in various aspects of imaging technology development.

The perspective transformation automation in this study was carried out by separating 2 different processes. The use of 2 stages is intended so that the automation system can work effectively. The first stage is used to identify the four coordinates used in the perspective transformation, which is only done once the first time the system is used or during maintenance so that the system is able to correctly identify the expected area. This process involves a red auxiliary circle placed in a certain position as a marker for the position of the coordinates to be identified. The second stage is the process of identifying the status of the parking slots, this stage is similar to the previous study system. The difference is that in the previous study [8] the transformation coordinates were still inputted manually, in this study the system will load the transformation coordinates that were obtained at the previous stage. A more detailed explanation of the system development carried out is in the next section.

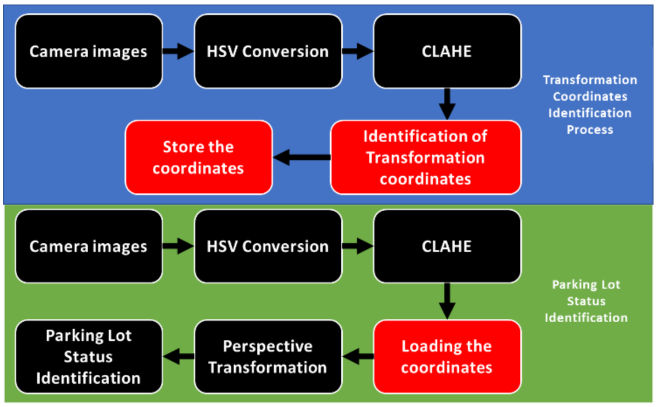

Fig. 1. System block diagram

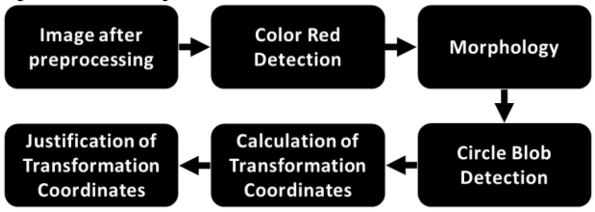

Fig. 2. Block diagram of transformation coordinates identification

II. Methods

System block diagram is shown in Fig. 1. The red block shows the focus area of this study, namely perspective transformation automation. The block diagram is divided into 2 stages of the process, namely identification of perspective transformation coordinates stage, and identification of the parking lot status stage. In the first stage, all coordinates for the transformation will be identified and then stored in a file. At the identification stage of the parking lot status, all of these coordinates will be loaded for use in the perspective transformation algorithm.

Fig. 2 shows the block diagram of coordinates point identification automation for perspective transformation. This automation is carried out by conditioning the parking area without vehicles or other objects that are not needed. This automation using some auxiliary circles to identify transformation coordinates and parking space status. Image that has passed the initial processing is used as input for the next process. Red circle detection is done using a blob detection algorithm with a red filter. After all auxiliary circles are detected, calculation and justification of all coordinates for perspective transformation is performed. The calculation phase is executed when the system cannot immediately find the desired transformation coordinates because it is blocked by foreign objects such as trees or auxiliary circles that detect more than needed. The justification stage is used to determine and store all the coordinates needed for the perspective transformation.

A. Blob Detection

To help the system determine the perspective transformation coordinates automatically, a blob detection algorithm is used. Blobs usually show areas with different colour levels from the environmental domain [20]. This algorithm will find auxiliary circles that have been positioned in the parking lot as needed.

Fig. 3. Red auxiliary circle with 60 cm in diameter

Fig. 4. Location of the red auxiliary circle for case 1

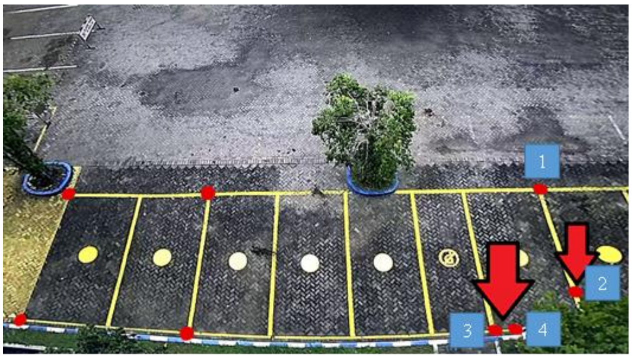

Fig. 5. Location of the red auxiliary circle for case 2

TABLE I. BLOB IDENTIFICATION PARAMETERS

Parameter	Value
minCircularity	0.7
minArea	20
blobColor	255

Red auxiliary circles used in this study can be seen in Fig. 3. The red colour is used to contrast the auxiliary circles with the surrounding area in the captured image and to differ it from the auxiliary circles used in status identification. Each of the red auxiliary circles is 60 cm in diameter.

In this study, two cameras were used to obtain two images with different conditions. Two different images are used to show the different results of the implementation of the transformation automation. The first image shows an image with the location of the transformation coordinates not obstructed by any object. In another image, there are transformation coordinates whose locations are blocked by trees. Based on the two image cases, the auxiliary circle is placed in such a way that all transformation coordinates can be identified by the system.

Fig. 4 shows the placement of the red auxiliary circles for the first case. Meanwhile, the placement of auxiliary circles for the second case is shown in Fig. 5. In each case image there are two auxiliary circles which are not used in the identification of perspective transformation coordinates. This is because the capture spaces of the two cameras intersect at a certain point, resulting in the position of the two auxiliary circles of the first camera being visible on the second camera and vice versa.

In the first case all transformation coordinates can be obtained by identifying the location of the red auxiliary circle and taking 4 points between them. In the second case, because there is an obstacle in one of the transformation coordinates and the captured image has a convex nature, more auxiliary circles are needed so that the required coordinates can be identified properly. At least 4 auxiliary circles are needed to get 1 coordinate point of the transformation referred to by utilizing the theory of intersection of lines. The coordinates of the two circles are the coordinate representations of the first line equation and the coordinates of the other two circles are the coordinates of the second line equation, with the two intersecting at one point, namely the identified transform coordinates.

Before implementing the blob detection algorithm, the red object filter algorithm is applied first. Color filters are provided by setting the red upper and lower limits of the Hue segment in the HSV image color space. After obtaining the red filtered image, the image is then processed with a morphological algorithm to get a better blob. Furthermore, the blob detection algorithm is used to find blobs that meet the parameters. Detailed parameters used in this circular blob detection can be seen in Table 1. Mincircularity parameter is used to set the minimum circularity value of the blob to be identified, its value ranges from 0-1. The higher the circularity value, the rounder the blob will be. minArea parameter is used to set the minimum value for the identified blob area. There are no limit values for this parameter. blobColor parameter is used to set the color of the blob to be identified. In this study the blob to be identified is white from a binary image.

B. Transformation Coordinate Calculation

Only 4 coordinates are needed in the implementation of the perspective transformation algorithm. However, in this study it is possible that more than 4 auxiliary circles will be detected in one image. This is based on the minimum number of auxiliary circles captured by the camera, which is 6 auxiliary circles. Therefore, in this study it is necessary to calculate the 4 coordinates.

The calculation of the 4 perspective transformation coordinates is divided into 2 types. First is calculation for the unobstructed image case. In this case, all detected blobs will be sorted according to their x and y coordinates. Then, 4 transformation coordinates are taken with the details of the two leftmost coordinates and the two rightmost coordinates. Second is calculation for the case of images with obstacles.

In this case, all detected blob coordinates are also sorted as in the first case. Except for coordinate that is blocked by trees, the other 3 coordinates are taken without special calculations with the same rules as the calculations in the previous case. For coordinates that are blocked by trees, calculations are performed using the intersection equation of the lines. 4 auxiliary circles are used to form 2 intersecting lines, so that the desired coordinates can be deduced from the intersection. Fig. 6 shows the intersection of the lines of the four auxiliary circle coordinates. From the four coordinates of the circle, it can be calculated the gradient of the 2 lines referred to (1).

$$m = \frac{y2-y1}{x2-x1} \quad (1)$$

Calculation of the gradient of the two intersecting lines is done by utilizing the coordinates of the circle forming the line, namely (x1, y1) and (x2, y2). The gradient of the two lines is then called m1 and m2.

$$y = mx + c \quad (2)$$

$$c = y - mx \quad (3)$$

From (2), value of each constant of the two line equations can be calculated by (3). By utilizing the values of m1, m2, (x1, y1), and (x2, y2) in the two line equations, the constant values of the two line equations, c1 and c2, can be known.

From the gradients and constants of the two lines, the intersection coordinates can be calculated. To get the intersection value of the x and y coordinates, (4) and (5) can be used respectively.

$$x\_coordinate = \frac{c2-c1}{m2-m1} \quad (4)$$

$$y\_coordinate = m1(x\_coordinate) + c1 \quad (5)$$

The value of x coordinate can be obtained by comparing the difference between two constants of the line equation with the difference between two gradients of the line equation. Meanwhile, the calculation of y coordinate can be obtained by substituting the gradient, constant, and x coordinate values that have been obtained into one of the line equations. The x and y coordinates then become the fourth coordinate needed in the perspective transformation. So that it is the same as in the first case, in the second case we get 4 coordinates for the perspective transformation.

C. *Transformation Coordinate Justification*

At this stage, checking order of the four coordinates obtained in previous stage is carried out. This check was carried out in both identification cases. The four coordinates are sorted according to order of top left, top right, bottom left, and bottom right coordinates or as shown in Fig. 7. If these rules are met, the coordinates will then be stored in a file that will be used continuously for transformation purposes. Perspective on identifying the status of outdoor parking lots.

D. *Identification Status Slot Order*

In this study, the identification status slot order can be seen at Fig. 8 for the transformation coordinates without obstacles case, and Fig. 9 for the transformation coordinates with obstacle case. The slot order is written from slot 1 until 6 in each case, because that is the parking slots that can be covered by both camera in this study. This slot order will be used for writing data and evaluation in the next section.

E. *Parking Slot Status Identification*

In this study, identification of parking slot status was carried out in the same way as in previous study [8]. There are empty and occupied status. Identification of the status of each parking slot takes advantage of the yellow auxiliary circle located on the associated slot. In short, if the results of image processing in a slot detect a blob from those yellow auxiliary circle that matches the parameters, then the slot is said to be empty or available. This represents the condition that there are no vehicles in the parking slot, so that the auxiliary circle in the parking space can be detected. On the other hand, if the results of image processing on the associated parking slot do not detect any such blob, then the parking slot is labeled as occupied. This condition represents the presence of a vehicle in the parking slot, so that the auxiliary circle in the slot is covered by the vehicle and causes the auxiliary circle to not be detected.

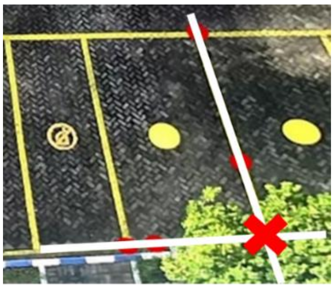

Fig. 6. Ilustration of coordinate position with 2 lines intersection

Fig. 7. The order of transformation coordinates

Fig. 8. Parking slot order for case 1

Fig. 9. Parking slot order for case 2

TABLE II. Range Of Illuminance Value For Each Condition Range

Condition	Illuminance value (Lx)
Morning	43.898-149.322
Afternoon	43.172-132.431
Evening	8.579-38.576

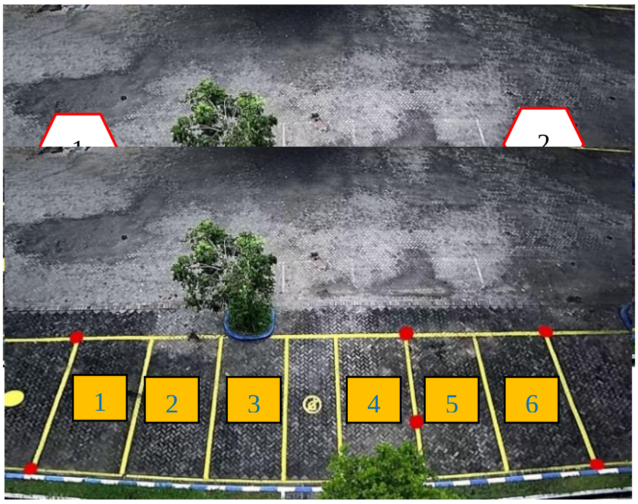

TABLE III. SUCCESS RATE OF COORDINATES IDENTIFICATION AND THE TRANSFORMATION

Case	Condition	Sample	Coordinates Identification Success Rate	Transformation success rate
1	Morning	10	100%	100%
	Afternoon	10	100%	100%
	Evening	10	100%	100%
2	Morning	10	100%	100%
	Afternoon	10	100%	100%
	Evening	10	100%	100%

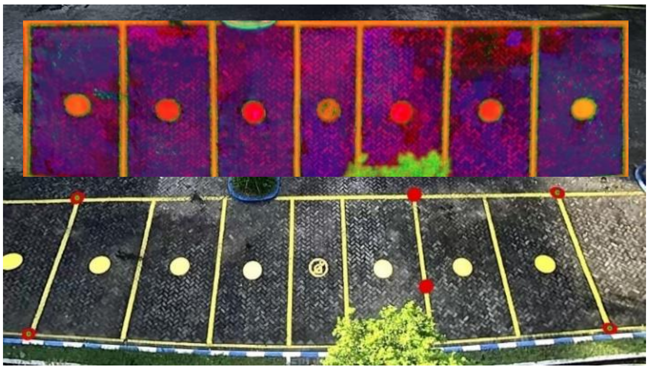

Fig. 10. Result coordinates identification and its HSV transformation image for case 1

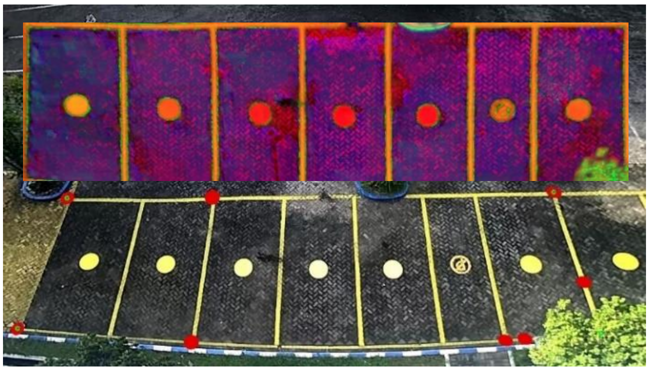

Fig. 11. Result coordinates identification and its HSV transformation image for case 2

F. Recall, Precision, and Accuracy

Analysis of recall, precision, and accuracy is used in this study to determine capability level of the system that has been developed. Recall in (6) is a measure of the proportion of positives that are correctly identified by comparison of total true positives to overall total positives. In contrast, precision in (7) is a measure of proportion of correctly identified negatives. While accuracy in (8) is comparison of total value that is correctly identified to total value of existing identification.

$$recall = \frac{TP}{TP+FN} \quad (6)$$

$$precision = \frac{TN}{TN+FP} \quad (7)$$

$$accuracy = \frac{TP+TN}{TP+TN+FP+FN} \quad (8)$$

In (6), (7), and (8) used TP, TN, FP and FN variables. Variable TP (True Positive) is a positive value that is correctly identified. While TN (True Negative) is a negative value that is correctly identified. FP (False Positive) is a positive value that is incorrectly identified or identified as a negative value. Last, FN (False Negative) is negative values identified as positive values. In this study, a negative value is identified with an "empty" parking slot status condition which means there are no vehicles in the parking slot while a positive value is identified with a "occupied" parking slot status or there are vehicles in the parking slot.

III. RESULTS AND DISCUSSION

This section discusses the results of the implementation of perspective transformation automation algorithm on identification status of outdoor parking lots. The discussion of the results is divided into 3 sub-sections, namely results of implementing automated image perspective transformation to be identified, calculation of recall, precision, and accuracy of the system in 2 cases of captured images, and comparation with the related research. Both cases are images without obstacles and images with obstacles, as explained in previous section.

Data was taken at various times, namely in the morning, afternoon and evening. The conditions are outlined in the lux/illuminance values in Table 2. In morning data collection, it can be seen that the illuminance values vary from around 43.898 lux to 149.322 lux. This is the widest variation in data collection that has been done. Followed by variations in illumination during the day whose value is almost the same as the conditions in the morning. In the afternoon, illuminance value tends to be lower than in the morning and afternoon, which is between 8.579 to 38.576 lux.

A. Perspective Transformation Automation

Table 3 shows the success rate of identification of transformation coordinates and also the success rate of the transformation. With 10 image samples for each case and each condition, 100% of all transformation coordinates in both cases can be identified with precision and can be transformed as expected. Sample images of coordinates identification and its perspective transformation results for each case can be seen in Fig. 10 and Fig. 11. The green dot in coordinates identification image indicates the location of the identified coordinates. As for the transformation images, it is displayed in HSV color space.

This automation is expected to reduce time consumption. So, in this study, time of preparation and coordinates identification is measured. In this part, preparation means a process where the auxiliary circle is placed at the desired point in parking lot. Table 4 shows average time of preparation and coordinates identification for each case in some conditions. According to the table, average times needed for this automation is 31.689 seconds, with the average preparations time is 30.326 seconds and the average identification time is 1.363 seconds. Some factors affect the preparations time, such as step width and walking speed. So, it is possible that the system can be faster or slower regarding the operator physical movement. In this study, all kind of preparation is done by one similar operator. As for identification time, it depends on condition of the machine/processor. The healthier the processor, the more optimal the identification time.

B. *Identification After Automation*

Calculations of the recall, precision, and accuracy of each condition described in previous section were carried out in both cases based on the identification results that had been obtained. The results of the recall calculation for each case can be seen in Tables 5 and 6. From the table it can be concluded that in all conditions in the two cases the system has a recall of 100%. This means the system has been able to identify the “occupied” parking slot status without error. An example of matrix calculations using equation (6) in this experiment is the calculation of 4^{th} parking slot in the morning from case 1. 100% recall on the related slot and conditions is obtained from 23 TP and 0 FN. It means that out of 300 samples, 23 of them were samples when the slot is “occupied” and the proposed system was able to identify them correctly.

TABLE IV. AVERAGE TIME OF PREPARATION AND COORDINATES IDENTIFICATION BY 10 SAMPLES IN EACH CONDITION

Case	**Condition**	**Average time**		
		Preparation (s)	**Coordinate Identification (s)**	**Total (s)**
1	Morning	29.458	1.335	30.793
	Afternoon	30.976	1.362	32.338
	Evening	30.849	1.36	32.209
2	Morning	29.42	1.349	30.769
	Afternoon	30.774	1.392	32.166
	Evening	30.482	1.378	31.86
Average		30.326	1.363	31.689

TABLE V. PERCENTAGE OF RECALL FOR EACH PARKING SLOT IN CASE 1

Time	**Parking Slot**					
	1^{st} (%)	**2^{nd} (%)**	**3^{rd} (%)**	**4^{th} (%)**	**5^{th} (%)**	**6^{th} (%)**
Morning	100	100	100	100	100	100
Afternoon	100	100	100	100	100	100
Evening	100	100	100	100	100	100

TABLE VI. PERCENTAGE OF RECALL FOR EACH PARKING SLOT IN CASE 2

Time	**Parking Slot**					
	1^{st} (%)	**2^{nd} (%)**	**3^{rd} (%)**	**4^{th} (%)**	**5^{th} (%)**	**6^{th} (%)**
Morning	100	100	100	100	100	100
Afternoon	100	100	100	100	100	100
Evening	100	100	100	100	100	100

TABLE VII. PERCENTAGE OF PRECISION FOR EACH PARKING SLOT IN CASE 1

Time	**Parking Slot**					
	1^{st} (%)	**2^{nd} (%)**	**3^{rd} (%)**	**4^{th} (%)**	**5^{th} (%)**	**6^{th} (%)**
Morning	100	51.1	82.7	49.8	99	100
Afternoon	95.6	98.9	95.3	75.3	81.6	99.3
Evening	100	100	100	99.6	100	99.6

TABLE VIII. PERCENTAGE OF PRECISION FOR EACH PARKING SLOT IN CASE 2

Time	**Parking Slot**					
	1^{st} (%)	**2^{nd} (%)**	**3^{rd} (%)**	**4^{th} (%)**	**5^{th} (%)**	**6^{th} (%)**
Morning	99.6	99.3	99.2	51.1	83.6	71.1
Afternoon	100	99.6	94.6	97.9	97	88.5
Evening	100	100	100	100	100	100

Fig. 12. Original and binary image of failed identification status in case 1

Next, precision values of each case are presented in tables 7 and 8. From the table we can see that in majority of parking slots the two cases have a precision value of less than 100%. This indicates that the system has not been able to identify "empty" parking slots perfectly. Even some slots have a precision value of less than 70%. An example of matrix calculations using equation (7) in this experiment is the calculation of 4^{th} parking slot in the morning from case 1. 49.8% precision on related slot and conditions is obtained from 138 TN and 139 FP. It means that out of 300 samples, 277 of them were samples when the slot is “empty”, but unfortunately the proposed system is only able to identify 138 samples correctly and the rest were not. The low precision value of the identification is caused by a system error in identifying "empty" status of parking slot as "occupied". This identification error is caused by several things, including the presence of shadows of other objects when illuminance value is high, and presence of reflections from auxiliary circle which results in image conversion errors. Identification errors that occurred in case 1 mostly occurred in 2^{nd} and 4^{th} parking slots with precision percentage below 55%. Whereas in case 2, the percentage of precision is less than 55% occurring in 4^{th} parking slot.

In case 1, precision value was low in the morning. As for during the day, the 4th parking slot also has a fairly low percentage. The cause of this is the same as the cause of misidentification in the morning. This identification error occurs when the illuminance value is high, one of the effects of which is to cause reflections on the auxiliary circle used in the identification process. Another effect is the presence of shadows from trees, which the system has not been able to perfectly suppress. Fig. 12 shows an example of an identification error original and binary images in case 1. According to the original figure, the result should be empty for all slots except 4th slot, because there is a car. But, it turns out as occupied in 2nd slot, so it is clear that this is an identification error.

Case 2 which looks more stable also has the same constraints as case 1. Identification errors also occur with the same factors as case 1. Failure to form a binary image is expected to be the exact cause. It can be seen that in case 2, the system has a low precision in 4th parking slot. Followed by low precision in 6th parking slot in the morning. From both cases it can be seen that the higher the illuminance value, the possibility of identifying "empty" as "occupied" also increases. Fig. 13 shows an example of a binary image that failed to be identified in case 2. According to the original figure, the result should be empty for all slots except 4th slot, because there is a car. But, it turns out as occupied in 5th slot, so it is clear that this is an identification error.

TABLE IX. PERCENTAGE OF ACCURACY FOR EACH PARKING SLOT IN CASE 1

Time	Parking Slot					
	1st (%)	**2nd (%)**	**3rd (%)**	**4th (%)**	**5th (%)**	**6th (%)**
Morning	100	56.3	84	53.7	99	100
Afternoon	96	99	95.7	80.7	82.3	99.3
Evening	100	100	100	99.7	100	99.7

Tables 9 and 10 describe the accuracy calculation results for each case. The accuracy percentage value that is less than 60% in case 1 is indicated in the identification of 2nd and 4th parking slots. Whereas in case 2 it is indicated in 4th parking slot. An example of matrix calculations is matrix calculations from case 1. 53.7% accuracy on 4th slot in the morning is obtained from 23 TP, 0 FN, 138 TN and 139 FP. From the calculation using equation (8), the accuracy value is then obtained. In this study, the low accuracy percentage value was caused by many identification errors "empty" as "occupied". The small value of accuracy in both cases only occurs in the morning according to the precision value which is only low in the morning in the same slot. However, the accuracy in other slots shows high numbers, the majority are above 95%. The high accuracy value indicates that the system already has good reliability in the majority of parking slots, even though it is imperfect.

C. *Comparison with Related Research*

The only data that can be compared to this study from previous research [8] is identification status of each parking slot data. The data to be compared with the previous study is identification data of case 2 images with low illuminance, in other words the data of case 2 in evening. The data is chosen because the shooting angle and lighting conditions are close to previous studies. Table 11 shows data comparation between this studies with the previous research. There is no problem in recall, both researches give perfect result. As for the precision, the system has perfect value, it is better than previous research that have value below 100% at 4th and 5th parking slot. This conditions also occur in accuracy analysis, the system is more reliable in the afternoon with 100% of all slot can be identified perfectly. With these results, it is clear that this automated system is more reliable and more effective than the previous system.

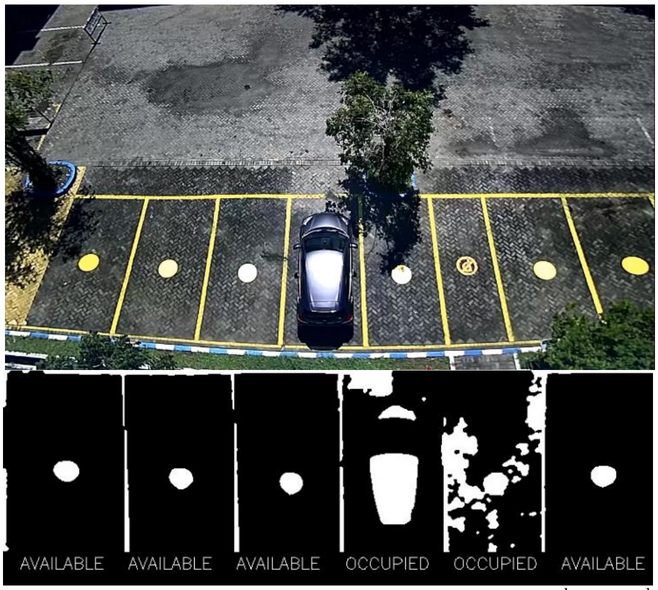

Fig. 13. Original and binary image of failed identification status in case 2

TABLE X. PERCENTAGE OF ACCURACY FOR EACH PARKING SLOT IN CASE 2

Time	Parking Slot					
	1st (%)	**2nd (%)**	**3rd (%)**	**4th (%)**	**5th (%)**	**6th (%)**
Morning	99.7	99.3	99.3	56.3	85	81.3
Afternoon	100	99.7	95	98	97.3	92.3
Evening	100	100	100	100	100	100

TABLE XI. COMPARISON BETWEEN THE PROPOSED SYSTEMS WITH THE PREVIOUS RESEARCH

	Subject	Parking Slot					
		1st (%)	**2nd (%)**	**3rd (%)**	**4th (%)**	**5th (%)**	**6th (%)**
Previous Research	Recall	100	100	100	100	100	100
	Precision	100	100	100	97.4	97.6	100
	Accuracy	100	100	100	97.8	97.8	100
This Research	Recall	100	100	100	100	100	100
	Precision	100	100	100	100	100	100
	Accuracy	100	100	100	100	100	100

IV. CONCLUSION

This research automates the perspective transformation process in an outdoor parking lot identification system. By utilizing the detection of red auxiliary circles, the coordinates needed in the perspective transformation can be obtained.

For the case of coordinates that are blocked by other objects, coordinate detection is carried out by utilizing the theory of intersection of lines. The system automation test shows that 100% of the system has been able to identify the transformation coordinates and carry out the perspective transformation process as expected. The identification capability of the system is then tested at 3 different times. Of the 900 samples in each case, the percentage of recall obtained was 100%. Meanwhile, the percentage of precision and accuracy for each parking slot has varied values, with most of them being above 85%. Compared to previous studies, the proposed system is more effective, with recall, precision, and accuracy values at 100% at low illumination in case 2. The effectiveness of the proposed system is even more evident with average data automation time is 31.689 seconds. With some lack of the proposed system, the next research could use polarizer to improve the performance of the system or by change some algorithm such as changes the color space to Lab not HSV.

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