Detection of Empty Slots in Car Parking System Using Neural Network Method

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Abstract. There are many transportation equipment such as a car, a motorbike in Indonesia. Increasing the volume of vehicle users will increase parking activities in every public place. Parking is a condition of a vehicle that is not temporary. The current parking system still uses a conventional parking system that only utilizes parking lots and parking officers who control each vehicle that enters, and often do not pay attention to the capacity of parking space that has been provided and often drivers go around first to find an empty parking lot. Therefore, detection of empty slots in the parking system is needed. To obtain this information, this study using a neural network method. The neural network is one of the information processing systems designed by imitating the workings of the human brain in problem-solving. The purpose of this research is to determine which car parking slots filled or empty parking slots. The results of detection of car parking slots using a neural network method were carried out experiments on 20 objects with as many as 12 slots and with three slots that are rectangles, squares, and traingles. In the square slot with an area of 784 cm² get accuracy results 100%, rectangular slots with an area of 3.608 cm² obtained accuracy 95% and a traingle slot with an area of 1.804 cm² obtained an accuracy 90%.

1. Introduction
Technological developments and increasing human needs are things that influence each other. The increased human need to trigger technology developments, while technology developments trigger negative effects of new technology. An example needs to use transportation equipment such as a car, motorbikes, and other public transportation equipment. The total volume of vehicle users such as cars and motorbikes in Indonesia is very much. The increasing volume of vehicle user will increase parking activities in every public place such as offices, campuses, shopping centers.

The current parking system still uses a conventional parking system that only utilizes parking lots and parking officers who control each vehicle that enters, and also often does not pay attention to the capacity of parking space owned by a building. This cause loss from the vehicle owner because the driver does not know where parking lot empty and forced to leave if not find an empty parking lot. Parking lots are important facilities that must be owned by a public place. Most of the parking lots have large land so drivers are difficult to reach parking lots.

The process of detecting the availability of parking slots will be obtained using a neural network method. A neural network is a method whose pattern follows the work human nervous system. Where the main processing of the human nervous system lies in the brain. In utilizing a neural network method, visitors will find it easier to get a parking space.
2. Study of Literature

2.1. Introduction to Parking
Parking is the condition of a vehicle that is not temporary, while parking facilities are locations that are determined as a temporary stop for vehicles to carry out activities in a period. [1]

2.2. Slot
The system can detect the condition of parking slot whether parking slot in a parking lot is still empty or has been filled. Parking space is used as input from a system. [11]

2.3. Artificial Intelligence
Artificial intelligence is one of the computer sciences that makes the machine (computer) can do the work as well as what humans do. Artificial Intelligence is a branch of computer science which in representing knowledge uses more forms of symbols than the number and processes information based on heuristic methods or based on several rules. [6]

2.4. Deep Learning
Deep learning is one of the fields of machine learning that utilizes many nonlinear information processing layers to perform feature extraction, pattern recognition, and classification. [3] Deep learning is an approach to solving problems in computer learning systems that use hierarchy concept. Hierarchy concept makes computers capable of learning complex concepts by combining simpler concepts. If a graph is illustrated how the concept is built on another concept, this graph will be deep with many layers, this is reason referred to as deep learning. [5]

2.5. Neural Network
Neural Network is a method whose pattern follows the work of the human nervous system. Where the main processing of the human nervous system lies in the brain. The smallest part the human brain is nerve cells which are the basic units for information processors. This unit is called a neuron. Around 10 billion neurons in each human brain and around 60 trillion connections between neurons in the human brain. [2]

2.6. The Architecture of Artificial Neural Networks
The arrangement neurons and the pattern of interconnections between layers are called net architecture. Artificial neural network architectures are classified as a single layer, multilayer, and competitive layer. To determine many layers used, input layer not included as the layer used. The number of layers included in artificial neural networks shows the number of weight values associated between these layers because weight values were important in artificial neural networks. [10]

2.6.1. Single-layer-net
The single-layer net has one layer to connect its weight value. Input neurons are directly related to output neurons. This network only receives information and directly processes it into output without going through the hidden layer. The characteristics of this single-layer-net have only one input layer and output layer.

2.6.2. Multilayer net
Multilayer net is a network that has one or more additional layers (hidden neurons) between the input and output layers. This multi-layer network to solve more complex problems than networks with one layer.

2.6.3. Competitive layer net
Competitive layer net consist of two or more artificial neural networks. This network architecture can connect one neuron with another neuron.
3. Research Method

3.1. General Architecture
Following is the general architecture of the application:

![General Architecture](image)

Based on figure 1, it can explain that: (1) The first process is labeling for each available parking slot, labeled parking slots marked with blue slots. The purpose of this labeling is to be easily recognized by each slot, (2) After the labeling process, it was followed by testing, the image shows an empty slot, where the empty slot is indicated by a green slot. In this testing phase, there is a pre-processing stage that is followed by laplacian of gaussian operators where pre-processing is a process used to improve the quality of image display to have a better format so that the image becomes easy to process to be good edge detection. The gray scaling process is used as pre-processing. The gray scaling process is the process of converting images that have colors to images that have a gray level. The edge detection process here uses a laplacian of gaussian operator developed from the second derivative, the gaussian followed by the Laplace operation. (3) Next, there is a car object entering the available parking slot. Then the car object goes to slot 1 and slot 3. if the car object enters an empty slot, the parking area will be full. (4) After the car object enters the parking lot. Then the previous green slot turns red, the process of changing the color of this slot because it has passed the pre-processing stage using the Laplacian of Gaussian operator.

3.2. Illustration of a Car Parking System
Slot manipulation:

![Slot manipulation](image)

Figure 2. Empty Parking Slot (a) Rectangular Slots (b) Square Slots and (c) Triangle Slots

Parking lots will be to design with five slots, slots marks in green if the parking lot is empty. If the car is parked, it turns red.
Based on figure 4 above, some slots are filled which are marked with red slots and green slots indicating empty slots. The color will change if the parking area has been placed by the visitor.

3.3. Car Parking System Using a Neural Network

The mechanism of the car parking system using the neural network is as follows:

The initial data slot that the system receives is in the form of coordinate parking slot data. Where the coordinates of the parking slot are obtained from the size of the pixel image used. The slot detection process is where the object will go to the available slot on the parking lot. The empty slot is marked with a green slot and the slot is filled with a red slot. In this process there is a pre-processing stage, where pre-processing is the initial stage in this research process which is used to apply several effects to be processed in order to continue the next stage and the pre-processing stage is also used to improve the
quality of the image display to have a format better so that the image becomes easier to process further to detect objects.

3.3.1. Empty Parking Classification Process
At this stage input the image of the empty parking slot, then the user can specify the parking slot where the parking slot can be rectangular, square and triangle. At the pixel calculation stage, initially, it is seen from the pixel of the entire image that has been inputted before. Example: pixel of an image of 520 x 320 which is 520 as the width and is the coordinate point of the x-axis and 320 as the height which is the coordinate point of the y-axis. Then in the Laplacian of Gaussian process there is a pre-processing process, where pre-processing is the initial stage in the research process that is used to apply several effects to be processed to continue the next stage and the pre-processing stage is also used to improve the image display quality to have a better format so that the image becomes more easily processed further to detect objects. The process used in the pre-processing stage is the Laplacian of the Gaussian operator. Where laplacian of gaussian is an edge detection operator developed from derivative of two processes, namely, Gaussian followed by Laplace operation. The function of the gaussian is to reduce noise while the Laplace operation is used to minimize the possibility of error detection. The approach with the Laplacian of Gaussian operator starts with an image blurring process where the blurring process is used to reduce noise with blur, then followed by a grayscale process, after going through the grayscale process, then the final stage is the laplacian stage. The slot data obtained is in the form of coordinate data from each slot that has been describing in the previous process as in figure 6.

![Figure 6. Empty Parking Classification](image-url)
3.3.2. Neural Network Process
As follows:

![Flowchart Neural Network](image)

In this process, the first step is a random input initialization. Random initialization is the method most often used in weight initialization, where weights are initialized randomly without using a scale factor. Then specify the input data and target data. Also, specify training data and test data. Then create a feed-forward (back feed), backpropagation 3 network layers. Backpropagation consists of many layers (multilayer), namely the input layer, at least one hidden layer, and the output layer. In the output layer and hidden layer, each one is given a value that can be 1. Next, to train the network, there are 4 processes in this process, namely calculating gradient errors in the output layer, updating the hidden layer weight to the output layer, calculating the gradient error in the hidden layer and update the input layer weight to the hidden layer.

4. Results and Discussion

4.1. Parking Slot
The parking slots contained in the system are rectangular, square slots and triangle slots.

![Rectangular Slots](image)
The rectangular slot above has an area of 3,608 cm\(^2\) with a length of 82 cm and a width of 44 cm. Each slot is given a number 1 to 12 marks that are used to get to know the slot. Square slots are as follows:

![Figure 9. Square Slots](image)

The square slots above have an area of 784 cm\(^2\) with each side length of 28 cm. Triangle slots are as follows:

![Figure 10. Triangle Slots](image)

The triangle slot above has an area of 1.804 cm\(^2\) where the base is 44 cm and height is 82 cm.

4.2. Object of Car
The data used is data determined by the researcher. Data consists of 20 car objects.

| Table 1. Object of Car |
|------------------------|
| Object | Figure |
| 1\(^{st}\) Object | ![Image] |
| 2\(^{nd}\) Object | ![Image] |
| 3\(^{rd}\) Object | ![Image] |
| 4\(^{th}\) Object | ![Image] |
| 5\(^{th}\) Object | ![Image] |
| Object | Image |
|--------|-------|
| 6th Object | ![Image](image_url) |
| 7th Object | ![Image](image_url) |
| 8th Object | ![Image](image_url) |
| 9th Object | ![Image](image_url) |
| 10th Object | ![Image](image_url) |
| 11th Object | ![Image](image_url) |
| 12th Object | ![Image](image_url) |
| 13th Object | ![Image](image_url) |
| 14th Object | ![Image](image_url) |
| 15th Object | ![Image](image_url) |
| 16th Object | ![Image](image_url) |
| 17th Object | ![Image](image_url) |
| 18th Object | ![Image](image_url) |
| 19th Object | ![Image](image_url) |
| 20th Object | ![Image](image_url) |
4.3. Test on the Parking Slot

4.3.1. Parking Slot Testing Based on Slot Area

This testing process uses 20 car objects with 12 slot slots. The following are the results of testing a rectangular slot with a slot area of 3.608 cm²:

| No. | Slot  | Total | Recognizable Object | Unrecognized Object | Figure |
|-----|-------|-------|---------------------|---------------------|--------|
| 1.  | Slot 1| 2     | 2                   | 0                   |        |
| 2.  | Slot 2| 1     | 1                   | 0                   |        |
| 3.  | Slot 3| 2     | 2                   | 0                   |        |
| 4.  | Slot 4| 2     | 2                   | 0                   |        |
| 5.  | Slot 5| 2     | 2                   | 0                   |        |
| 6.  | Slot 6| 1     | 0                   | 1                   |        |
| 7.  | Slot 7| 1     | 1                   | 0                   |        |
| 8.  | Slot 8| 2     | 2                   | 0                   |        |
| 9.  | Slot 9| 2     | 2                   | 0                   |        |
| 10. | Slot 10| 2    | 2                   | 0                   |        |
| 11. | Slot 11| 1   | 1                   | 0                   |        |
| 12. | Slot 12| 2   | 2                   | 0                   |        |
| Total|      | 20   | 19                  | 1                   |        |

The following is the percentage of accuracy from the results of testing table 2:

\[
\frac{20 - 1}{20} \times 100\% = 95\%
\]
Based on the calculation of the data, it was found that the average accuracy for the testing process of objects in slots was rectangular with an area of 3.608 cm$^2$ slots of 95%. The following are the results of testing a square slot with a slot area of 784 cm$^2$:

Table 3. Results of Testing Square Slots with Slot Area 784 cm$^2$

| No | Slot 1 | Total | Recognizable Object | Unrecognized Object | Figure |
|----|--------|-------|---------------------|---------------------|--------|
| 1. | Slot 1 | 2     | 2                   | 0                   |        |
| 2. | Slot 2 | 1     | 1                   | 0                   |        |
| 3. | Slot 3 | 2     | 2                   | 0                   |        |
| 4. | Slot 4 | 2     | 2                   | 0                   |        |
| 5. | Slot 5 | 2     | 2                   | 0                   |        |
| 6. | Slot 6 | 1     | 1                   | 0                   |        |
| 7. | Slot 7 | 1     | 1                   | 0                   |        |
| 8. | Slot 8 | 2     | 2                   | 0                   |        |
| 9. | Slot 9 | 2     | 2                   | 0                   |        |
| 10. | Slot 10 | 2     | 2                   | 0                   |        |
| 11. | Slot 11 | 1     | 1                   | 0                   |        |
| 12. | Slot 12 | 2     | 2                   | 0                   |        |
| Total | 20 | 20 | 0                   |        |

The following is the percentage of accuracy from the results of testing table 3:

$$\frac{20 - 0}{20} \times 100\% = 100\%$$

Based on the calculation of the data, it was found that the average accuracy for the testing process of objects in slots was a square shape with an area 784 cm$^2$ slots of 100%. The following are the results of testing a triangular slot with a slot area 1.804 cm$^2$:
Table 4. Results of Testing Triangular Slots with Slot Area 1.804 cm²

| No. | Slot | Total | Recognizable Object | Unrecognized Object | Figure |
|-----|------|-------|---------------------|---------------------|--------|
| 1.  | Slot 1 | 2     | 2                   | 0                   |        |
| 2.  | Slot 2 | 1     | 1                   | 0                   |        |
| 3.  | Slot 3 | 2     | 2                   | 0                   |        |
| 4.  | Slot 4 | 2     | 2                   | 0                   |        |
| 5.  | Slot 5 | 2     | 2                   | 0                   |        |
| 6.  | Slot 6 | 1     | 1                   | 0                   |        |
| 7.  | Slot 7 | 1     | 1                   | 0                   |        |
| 8.  | Slot 8 | 2     | 2                   | 0                   |        |
| 9.  | Slot 9 | 2     | 2                   | 0                   |        |
| 10. | Slot 10| 2     | 2                   | 0                   |        |
| 11. | Slot 11| 1     | 0                   | 1                   |        |
| 12. | Slot 12| 2     | 1                   | 1                   |        |
| Total |       | 20    | 18                  | 2                   |        |

The following is the percentage of accuracy of the test results table above:

\[
\frac{20 - 2}{20} \times 100\% = 90\%
\]

Based on the calculation of the data, the average accuracy for the object testing process in a triangle-shaped slot is obtained with a slot area of 1.804 cm² of 90%.

4.3.2. Test Results Based on Accuracy Value

The test results are based on the accuracy values obtained from the average accuracy for the testing process in a rectangular, square and triangular slot. Can be shown in the form of a diagram as follows:
Based on the graph (Figure 11) shows that if it has a small slot area (for example 784 cm²), the accuracy of the object is detected very well. The test is done by the state of the object stop at the same place, but only the shape of the slot is different. In rectangular slots, the value of accuracy is 95% where there is 1 car object that is not recognized by a rectangular slot. In the triangle-shaped slot with an area of 1.804 cm², the value of accuracy obtained is 90% because there are 2 car objects from 20 unrecognized car objects. Square slots with a slot area of 784 cm² all car objects can be recognized by a square slot so that it reaches an accuracy value of 100%.

4.4. Car Object Testing Based on the Middle Point of the Car Object Coordinate

4.4.1. Start Position and End Position of the Car Object

The following is the test result based on the coordinate midpoint of the beginning and end of a car object:

| No. | Object to Slot | Start Position (x,y) | End Position (x,y) |
|-----|----------------|----------------------|--------------------|
| 1.  | 1st object to Slot 3 | (505, 303) | (80, 215) |
| 2.  | 2nd object to slot 1 | (505, 303) | (74, 44) |
| 3.  | 3rd object to slot 4 | (505, 306) | (286, 48) |
| 4.  | 4th object to slot 10 | (506, 303) | (287, 214) |
| 5.  | 5th object to slot 3 | (507, 303) | (216, 52) |
| 6.  | 6th object to slot 8 | (507, 304) | (152, 210) |
| 7.  | 7th object to slot 9 | (506, 304) | (213, 215) |
| 8.  | 8th object to slot 12 | (506, 303) | (424, 211) |
| 9.  | 9th object to slot 5 | (506, 306) | (357, 52) |
4.4.2. Test Results Based on Start Position and End Position of the Car Object

The following are the test results based on the starting and ending positions of a car object, which can be illustrated with a graph as follows:

| Object | Start Position | End Position |
|--------|----------------|--------------|
| 10     | 10th object to slot 3 | (505, 304) (217, 52) |
| 11     | 11th object to slot 9  | (506, 303) (223, 195) |
| 12     | 12th object to slot 11 | (506, 303) (357, 214) |
| 13     | 13th object to slot 6  | (506, 304) (422, 50) |
| 14     | 14th object to slot 2  | (506, 303) (152, 52) |
| 15     | 15th object to slot 4  | (506, 304) (287, 48) |
| 16     | 16th object to slot 1  | (506, 303) (78, 39) |
| 17     | 17th object to slot 12 | (505, 303) (434, 206) |
| 18     | 18th object to slot 8  | (507, 306) (151, 210) |
| 19     | 19th object to slot 5  | (505, 305) (358, 49) |
| 20     | 20th object to slot 10 | (506, 304) (285, 206) |

**Figure 12.** Coordinate Graph of the Start Position and End Position of a Car Object

Based on the graph above, it can be analyzed that there are 20 car objects with each position of the starting and ending points of the car object coordinates, where 20 car objects will be detected with different forms of car parking slots, namely rectangular slots, square slots, and triangular slots. Based on the coordinate points of the car objects detects with rectangular slots there is 1 undetectable object, namely the 13th object with the coordinates of the initial position is (506, 304) and the 13th object stops in slot 6 where the coordinates of the final position is (422, 50), where the chart marked with a yellow plot. On car objects detect with square slots, each object from 20 car objects can detect properly In the car object detected with a triangle-shaped slot, there are 2 undetectable objects, namely the 8th object and the 12th object which are marked with a red plot, where the 8th object stops in slot 12 at the start coordinate point (506, 303) and the position of the object stops at the coordinate point (424, 211) and the 12th object stops at slot 11 at the start coordinate point (506, 303) and stops at slot 6 with the coordinates of the final position (357, 214).
5. Conclusion
Based on the results of the research conduct, it can be concluded that if the slot has an area with small size it can detect the location of the car properly. Level of accuracy obtained by 100% in the square parking slot with a smaller area than the rectangular slot and triangle slot. whereas if the parking slot has a larger area, for example at a rectangular slot has an accuracy rate of 95% and at the triangle-shaped slot has an accuracy of 90%. The start and final position of the car object also affect the object detected or not if the initial position is at the coordinate point (506, 303) and the position of the car object stops (357, 214) based on test the object cannot recognize. Based on the size of the car object, the object of the car does not affect the slot detected or not detected, because the thing that affects the success of this research is the area of each parking slot itself and the position of the stop of a car object.

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