AI Analysis of Illegal Parking Data at Seocho City

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Abstract The CCTV surveillance center (below to “Center”) in Seocho City Office operates 3724 CCTVs. CCTV control is operating infrastructure such as 40 Gbps self-fiber-connected network dedicated information and communication, 7 PB SAN storage and 200 virtual machines to ensure the safety of citizens. Center grow up the newest technique from now on. However, in view of Bia Data for illegal parking and stopping judgment in Center relies on the old automatic software. In this paper, we characterize images by local resident, neighborhood, site-specific, site-specific-direction, day of week, hour of day and analysis of Bia Data for judging illegal parking. We design an AI machine learning system that links the vehicle’s number recognition algorithm for illegal parking. Finally we design a advanced system that analyzes the status of illegal parking and stopping judgment in Seocho City Office, where Big Data and AI are connected using spatial information and AI.

Keywords CCTV · Deep learning · Video analysis · Illegal parking · Parking stop judgement

1 Introduction

The 4th Industrial Revolution technology is being applied to the real life of citizens. 5G smartphones receive information on the movement of patients with confirmed COVID-19 in Seocho City. 5G smartphone users can receive information from COVID-19 diagnostic tests, as well as phone connections with real-time map search and AI voice recognition and voice commands to avoid infection routes. While

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driving a vehicle, 5G smartphones take into account GPS and road traffic as well as video calls, and AI searches for the optimal vehicle driving route with a map and guides the vehicle with voice.

It is the traffic problem and garbage problem that Seocho City receives a lot of civil complaints for urban management. In traffic problems, especially illegal parking, which obstructs vehicle flow, is the most common complaint. To solve these traffic problems, Seocho City installed parking control CCTVs and expanded and is operating 348 parking control CCTVs in August 2020.

However, in the process of improving citizens’ life satisfaction and solving illegal parking, parking enforcement CCTV has not disclosed the enforcement process data. In addition, even after the illegal parking crackdown, only individual crackdowns are notified. Only simple information such as installation location is open on the website of Seoul and Seocho City as public parking control information [1, 2].

It is necessary to utilize the advanced technologies of the 4th Industrial Revolution to improve the efficiency of the CCTV operation for parking control in Seocho City. Parking control CCTV, introduced in Seoul city and autonomous districts since the late 2000s, has introduced some artificial intelligence machine learning supervised learning concepts, but in order to satisfy the actual parking control problem, the introduction of artificial intelligence deep learning is necessary. In other words, when determining the number of cases of parking enforcement CCTV analysis, reading, and administrative disposition, artificial intelligence designed a convolutional neural network of deep learning and an artificial intelligence algorithm for detection and optimal judgment to analyze actual parking enforcement CCTV and illegal parking. It should be applied to the crackdown.

AI-based vehicle discovery and vehicle number acquisition research are in progress like Vehicle license plate area detection using artificial intelligence deep learning [3], license plate recognition using polynomial-based RBFNNs [4], vehicle number recognition using data expansion and CNN algorithm [5]. The parking control method using artificial intelligence deep learning is a ReID technology for tracking criminal vehicles [6, 7] can be used. It also fits the government’s policy direction, which understands the 4th Industrial Revolution technology as improving administrative services to the public [8].

In this paper, after examining the actual parking control business process of Seocho City Office, we apply a binary machine learning method based on artificial intelligence supervised learning in the analysis and operation method of illegal parking control CCTV. In big data analysis, information on the parking control process in Seocho City is analyzed from the perspective of dong, time, day and system resources. In addition, for the efficiency and improvement of illegal parking enforcement in Seocho City Office, a parking enforcement method using artificial intelligence deep learning is designed and proposed.
2 Vehicle Number Recognition System Analysis

2.1 Data Preprocessing for Seocho City Vehicle Number Recognition and Extraction

In the case of vehicle number recognition using a contrast difference, the distance between the camera and the license plate, weather and shadows are greatly affected. So, in most cases, it is used the region binarization [9] and the morphology technique (open and close operation) [9]. Through this pre-processing, image quality improvement, lighting correction, and shadow distortion can be compensated.

2.1.1 Locally Adaptive Thresholding Method

Images captured in the field with a CCTV imaging device (CMOS) are difficult to identify images due to various lighting interferences. Therefore, the binarization technique is used to cancel unwanted illumination interference by using the contrast of the monochrome image.

There are many types of binarization. There is the simplest binarization method, global fixed thresholding method that binarizes based on a threshold value, but it is not easy to specify a license plate or vehicle number using this method alone. This is because the binarization success rate is high where the environment is prepared, but the possibility of binarization failure is high outdoors where there is a lot of lighting interference. Another method is Locally adaptive thresholding, which is used for calculation by subtracting a constant from the brightness average for each pixel of the image and calculating a threshold value like Fig. 1. This method is common [4].

![Fig. 1 Locally adaptive thresholding (Left) and global fixed thresholding (Right)
2.1.2 Image Morphology Technique

Since the binarized image is noisy, it is impossible to process it without correction. The method used at this time is the morphology technique. This technique maintains the characteristics of the image and processes only the shape change. Morphology is a concept similar to a mask and refers to a method of selecting pixels in an image in various shapes. Expansion, erosion, closing, and opening are possible as a method of calculating this, but generally in Fig. 2, opening and closing operations (Closing) removes noise and spots [4].

2.1.3 License Plate and Number Extraction

The outline of the binarized image in the previous section is displayed using findcontour among various functions of OpenCV. At this time, the license plate is determined using the unique ratio index of the license plate, and the number is then extracted by reflecting the ratio. If the ratio of the extraction number is not appropriate, the previous process is repeated to continue the process of finding the right license plate and number. Figures 3 and 4 is a picture of license plate and number extraction using findcontour function [4]. Various technologies have been developed to remove license plates and number distortion according to the shooting angle [10].
3 AI Machine Learning Analysis on Illegal Parking in Seocho City

3.1 Process Analysis for Illegal Vehicle Number Recognition

AI machine learning supervised learning expresses the process of recognizing the number of illegally parked vehicles in Seocho City. In order to increase the efficiency of parking enforcement, the performance of each process for recognizing the vehicle number is important. Only by improving the individual performance of each process can be expected to improve the license plate recognition rate.

Seocho City parking enforcement work process is shown in Fig. 5. Parking control CCTV attempts to recognize illegal parking vehicle license plates based on the same principle as AI machine learning supervised learning according to the already entered schedule. The CCTV control center manager visually checks the license plate information for illegally parked vehicles that were automatically cracked down the day before, deletes personal information, corrects errors, confirms the enforcement information, and issues a notice.
The parking control program installed on the Seocho City parking control host described in Fig. 7 checks the pre-registered schedule, checks whether parking is available date/time, and performs a preprocessing process of binarizing by controlling the camera. After finding the feature point, extracting the license plate and vehicle number in order, record it as a target for enforcement, and take pictures in wide view and narrow view (this is called 1st capture). It moves to the next preset defined in the setting to perform the vehicle detection process, and after a certain time elapses after the first site crackdown, it returns to the memorized angle of view and re-shoots to confirm the crackdown (this is called 2nd capture).

The currently used technology uses OpenCV-based supervised learning engine, Fig. 6, a more advanced AI machine learning algorithm is designed to operate as an AI machine learning supervised learning process.

3.2 AI Machine Learning for Illegal Parking Enforcement

Table 1 applied to Seocho City parking enforcement 348 CCTVs carried out 869,913 cases and 246,905 cases of first and second crackdowns for one year, of which only 10.427% of the first crackdown standards were actually fined.

Learning AI machine learning by dong in Seocho City

There are 18 dongs in Seocho City. Figure 7 represents the number of CCTVs installed in each building and the number of crackdowns in each building. It can be seen that the number of CCTVs is low in places with large-scale apartment
Fig. 6  Illegal parking software process

| Table 1  Operating result review |
|--------------------------------|
| Category | CCTV amount | Amount after 1st detecting | Amount after 2nd detecting | Amount of fault | Amount of judgment |
|----------|-------------|----------------------------|-----------------------------|-----------------|--------------------|
| Total    | 348         | 869,913                    | 246,905                     | 156,207         | 90,705             |
| Rate (Upper/1st) | –  | –                          | 28.383%                     | 17.957%         | 10.427%            |
| Rate (Upper/2nd) | –  | –                          | –                           | 63.266%         | 36.737%            |
complexes, and the number of CCTVs is high in places where shopping centers and offices are concentrated. It can be seen that the number of crackdowns is high in Seochon1-dong, Seochon2-dong, Seochon3-dong, Seochon4-dong, where there are many floating populations such as Gangnam Station and Express Terminal, and Banpo4-dong and Jamwon-dong. The peculiar point is that in Banpo-bon-dong, the amount of enforcement is small, but the detection error rate is low.

Figure 8 expresses the value obtained by dividing the number of crackdowns per
Fig. 9  Illegal parking amount comparison of daily timeline

donng by the number of cameras per dong based on the first crackdown result. You can see where the probability of finding a parked vehicle is high.

- **AI machine learning results by time**

  The parking enforcement time in Seocho City is from 08:00 to 24:00. From 12 o’clock to 14 o’clock, it is a grace time according to the meal time, and illegal parking is not regulated except for a few places that are very fatal to traffic Fig. 9. Crackdowns occur during the most active hours before and after lunch.

- **AI machine learning results by day of the week**

  Comparison of the number of parking enforcement by day of the week Fig. 10 shows that there is a strong tendency for illegal parking on Monday morning, Tuesday afternoon, and Thursday evening. Comparison of the number of parking enforcement on weekends Fig. 11 shows that there is a higher possibility of causing traffic jams due to illegal parking on Saturdays than on weekdays, and less than 30% of illegal parking on Sundays than on weekdays.
Fig. 10  Illegal parking amount comparison of week

Fig. 11  Illegal parking amount comparison of sun, mon and sat
4 AI Deep Learning Design to Improve Illegal Parking Enforcement Efficiency

4.1 AI Deep Learning System Design

It analyze and design AI deep learning algorithms and methods to make illegal parking enforcement and administrative disposition more efficient. For the maximum use of AI deep learning server resources, all servers have to adjust to virtualization based on hypervisor and operates thin provisioning.

4.2 AI Deep Learning Process Improvement Design

The current method of analyzing illegal parking enforcement video information and operating some AI supervised learning machine learning-based engines has many inefficient factors such as waste in process management and raising the question of administrative measures for enforcement. Illegal parking enforcement schedule is managed by AI supervised learning, but illegal parking enforcement vehicle and vehicle number recognition is Fig. 12, it is suggested to design with AI deep learning.

4.3 AI Deep Learning Algorithm Application Design

Supervised learning machine learning-based algorithm, which is a method of illegal parking control system, is shown in Fig. 13, the AI deep learning algorithm DNN (Deep Neural Network) is converted to improve the performance of the entire illegal parking process.

In AI Deep Learning DNN Algorithm, HL (Hidden Layer) 1 inputs illegal parking status, vehicle number recognition, elapsed time calculation for schedule, real-time status information, etc. as main functions to operate AI deep learning system and illegal parking control system Improves performance.

4.4 Improvement Effect When Applying AI Deep Learning

When AI deep learning and DNN algorithm are applied to illegal parking enforcement, improvement effects as shown in Table 2 can be obtained. Through AI deep learning and DNN algorithm, it can be applied to buildings where illegal parking enforcement and vehicle number recognition efficiency is low, thereby improving parking enforcement efficiency. In addition, by operating the deep learning DNN algorithm according to the number of cases in the field, the administrative power
of enforcement and prevention can be concentrated in the days and times of high frequency of illegally parked vehicles. The final goal, the 4th Industrial Revolution technology, can be reflected in administrative policy to increase the safety and satisfaction of citizens.
### Table 2 Comparison of AI machine learning versus AI deep learning

| Category                                      | AI machine learning (ML) | AI deep learning (DL) | Improvement effect                      |
|-----------------------------------------------|--------------------------|-----------------------|----------------------------------------|
| License plate recognition discrimination amount | 100 ch × 3 frames per second | ML × 4 times (Parallel processing) | Infrastructure efficiency improvement |
| Number of license plate recognition learning times | Manual learning in 1–2 times/month | DL algorithm self-learning | Labor cost reduction and improved accuracy |
| Illegal parking control judgment method       | Administrator visually checks and enters the ML | No intervention of high reliability algorithm by managers | Administrative power reduction by preemptive exception handling and labor cost reduction |

### 5 Conclusion

When operating illegal parking control CCTV, some methods of detecting vehicles and recognizing vehicle numbers are operated based on AI machine learning supervised learning. However, inefficient SW/HW operation, location/time/day of the week, etc., the classification and regression methods of machine learning supervised learning are not effectively reflected. Therefore, there is a problem in that a lot of effort and time are consumed by the administrator due to the uniform illegal parking control method.

In this paper, we presented big data analysis by reflecting situations such as SW/HW operation and winter/time/day of the week through classification and regression methods of AI machine learning supervised learning. In addition, AI deep learning DNN algorithm was designed based on the AI learning method results by analyzing AI deep learning in order to efficiently control illegal parking vehicles. In addition, in HL (Hidden Layer) 1 using the DNN algorithm, the AI deep learning system is operated by inputting illegal parking status, vehicle number recognition, elapsed time calculation for schedule, real-time status information, etc. as main functions. An improvement plan was designed to improve performance. By reflecting the AI deep learning system design, AI deep learning process improvement design, and AI deep learning algorithm applied design, the amount of illegal license plate recognition is increased by 4 times, the number of license plate recognition learning is reduced, the reliability of illegal parking enforcement judgment is improved, and real-time data mining The improvement effect on the possibility of report was confirmed.

In the future, research on algorithms that can be applied to more than 10 illegal parking control deep learning process variables and research that can apply deep learning to disaster situations and crime prevention using illegal parking control CCTV is needed.
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