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Implementation of efficient parking enforcement system using smartphone

Doyeon Kim
School of Computer and Information Technology
Daegu University, Gyeongsan, Gyeongbuk 712-714, Korea

Jaejoon Kim
School of Computer and Communication Engineering
Daegu University, Gyeongsan, Gyeongbuk 712-714, Korea

ABSTRACT

To date, parking enforcement systems have only been used by parking enforcement authorities, who detect and penalize violators. This paper introduces a modified version of the parking enforcement system utilizing smartphones that allows ordinary citizens to report parking violators to parking enforcement officers. The procedures of the system are taking a picture of a vehicle in violation, receiving the violation report virtually and finally reporting if violation car still remained at same location after five minutes have passed. The proposed system contains properties for transmission and receiving data about whether the complaint report of the violator's vehicle has been received in real time. It also works in conjunction with the existing parking enforcement system. This paper describes implementation of the proposed system.

Keywords*: Parking enforcement system, CCTV, PDA, smartphone, network packet, and mobility.*

1. INTRODUCTION

Parking surveillance systems have been thoroughly researched. Along with the development of electronic devices, parking enforcement system has been developed and used in CCTV and PDA based mobility. Current 3rd generation mobile communication handsets, smartphones, can be used to implement a parking enforcement system. Compared to previous parking enforcement equipment, smartphones enable the use of wireless Internet and can be used anywhere due to mobility.

The smartphone parking enforcement solution utilizes GPS in order to input time and location data. In this kind of system, enforcement authorities including citizens do not have to input time or location information manually. Just by taking a picture with a smartphone, the violating car's information is retrieved from the central database and entered into the designed system's input table. Anytime, anywhere, enforcement authorities can cite cars for parking violations. Information on car owners who frequently park illegally can be passed on to traffic wardens, anytime, anywhere.

With these features, everyone can be a warden. This system would efficiently decrease the inconvenience caused by parking violations. A brief introduction to the current parking enforcement system is provided in the next section. Application of the smartphone system for illegal parking enforcement is described in section 3. Results of implementing the method are presented in section 4. Concluding remarks are presented in the final section.

2. REVIEW OF PARKING ENFORCEMENT SYSTEM

Parking enforcement using cameras has been widely researched and implemented including mobile phone based enforcement, stationary unattended CCTV enforcement, mobile CCTV enforcement, and etc [1]-[6]. In recent years, the use of smartphones as a parking enforcement system has also been studied. This section introduces several parking enforcement systems.

2.1 Enforcement personnel

In most of countries, the right to enforce illegal parking violations is granted to police officers, and personnel designated by the Mayor or Governor. In previous parking enforcement systems, if there were no driver present for a parking violation vehicle, the enforcement personnel would put a citation on the windshield, take a picture and report the violation situation.

2.2 Fixed and mobile enforcement CCTV

In order to overcome limited time and limited human

* *Corresponding author, Email : jjkimisu@daegu.ac.kr*
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resources, the parking enforcement system has employed various unmanned enforcement equipment [7]-[9]. One method is fixed unmanned enforcement CCTV, which can fall into one of 3 classes. First, in a manual unmanned enforcement system an agent in a briefing room controls a CCTV camera remotely, recognizes the violation vehicle, and reports the plate number manually. Second, a semiautomatic system exploits plate recognition using a remote image and enforces the final decision for violation a few minutes later. Third, a fully automatic parking enforcement system sends a camera image to a briefing room in real time and manages the situation. This system issues a warning broadcast for the violation vehicle. It sequentially and automatically operates plate recognition, an inquiry of vehicle ownership, confirmation of enforcement, and ticket reporting after 5 minutes[1] [10]. It also allows violation enforcement with one or two agents.

Mobile CCTV utilizes a camera attached to a car which passes by illegally parked vehicles. The camera car takes a first shot with a rotating camera, and makes a decision whether vehicles are in violation after automatically taking a second shot 5 to 10 minutes later. This system has attached infrared light that enables plate recognition at night. It also contains a locating function using GPS information. Parking enforcement using this system minimizes the friction between car owners and enforcement officers while preventing waste of manpower. In order for the camera car to carry out enforcement activities safely, the car has special dispensation to park in some areas when carrying out enforcement. This is reviewed on a case by case basis.

2.3 Wireless Internet and mobile devices

Even though enforcement through CCTV had been used to overcome personnel limitations, in reality, the system was not able to catch many violations. However, improved performance and functionality in wireless Internet mobile devices such as PDA promised better enforcement systems.

In previous enforcement methods, personnel made violation reports and input violation information to a computerized information system. Wireless Internet mobile devices improve this process by taking evidence with a violation picture, recognizing license plates in real time and receiving plate numbers automatically [11-15]. With an embedded GPS receiver module, the mobile device obtains latitude and longitude coordinates at the violation point and can communicate the location and time of the violation to the data server. This system enables registration/modification/inquiry/ deleting functions of the vehicle through the main server.

2.4 Enforcement using smartphones

Currently, an enforcement system using smartphones, such as a 3rd generation Android phone, is under development [16-19]. In smartphone based parking enforcement system (SPES) as shown in Fig. 1, there are many benefits such as high portability and mobility. Table 1 shows characteristics of SPES. In addition, SPES can designate enforcement officer. In this system, for example, citizens designate themselves on a registered enforcement personnel list and report illegally parked vehicles with a picture, the time and location of the violation. Through the communication server, registered personnel recognize the violation plate and check the car registration DB. The DB server consists of information on the vehicle in violation, the registered personnel as well as car registration and provides easy access for enforcement personnel.

Fig. 1. A typical example for finding location via GPS

Table 1. Characteristics of Smartphone based Parking Enforcement System

Benefits	- High portability and mobility - High resolution with embedded camera - Usage of GPS - LBS (Location based service) - Easy distribution for App - Ubiquitous internet
Characteristics	- Less congestion due to lack of obstruction - Higher turnover of parking spaces make easier to park - Reduced pollution and fuel use due to less circulating traffic and less congestion - Safer streets due to less circulating traffic - Improved emergency service access due to less obstructed streets - Reduced demands on police resources

2.5 Parking Mobility[2]

Parking Mobility is initially a designed tool for disabled people to find parking sports assigned close to their purpose such as shopping. In addition, it has a reporting violation function for illegal parking used by people do not have a disability parking permit [20]. The one of major advantages is that people who do not have a parking enforcement authority can monitor the illegal parking. Generally, once people find an illegal parking on a disabled spot, people having a smartphone can take a picture of illegal parked car including license plate and report a disabled parking violation. This app software is shown in Fig. 2. Using people's smartphone GPS, the app can include time and location information to report a violation.

[1] Road Traffic Act Article 2 (Definitions) 25. 'Stop' means that the driver does not exceed five minutes before returning the car to a non-stop state.

[2] http://www.parkingmobility.com: Parking Mobility is a community-based non-profit organization which brings citizens and their cities together to address disabled parking abuse.

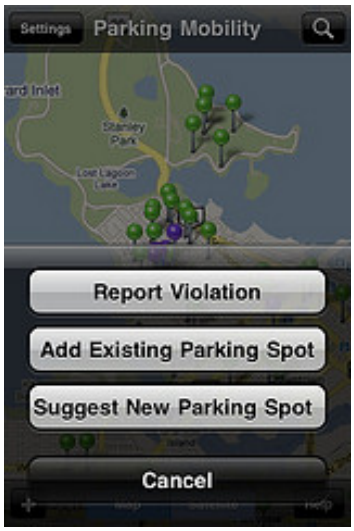

Fig. 2. iPhone screen shot of app for disabled parking [14]

3. EXPERIMENTAL DESIGN

In this experiment, the process is carried out as follows: If a user or registered personnel witnesses a vehicle parked illegally, they take a picture of the vehicle that shows the violation situation and automatically reports the generated location and current time at the moment of the violation. Once the violation report is received by the main server, the system analyzes the received picture, converts the character string and requests violation notification to personnel if violation criteria are met. This system cannot be executed for only one report. The violation criteria combine more than two virtual reports for the same vehicle, at the same location, and a parking time exceeding 5 minutes. In order to confirm that the report has been received, the personnel can access the server and check the violation report.

In addition, once users register their vehicles on the server, they can use their smartphone to check whether or not their vehicle was reported. This process allows the violator an opportunity to avoid a citation and also effectively reduces the inconvenience caused by illegally parked vehicles. The reporting status can be classified as shown in Table 2.

Table 2. Description of reporting status

Reporting status	Description
Receiving first report	Receiving violation report virtually
Request report	Receiving more than two virtual reports for the same vehicle, same location, and a parking time exceeding 5 minutes
Receiving second report-approval	The personnel checks the violation report and confirms violation approval
Receiving second report-rejection	The personnel checks the violation report and confirms violation rejection with insufficient evidence

3.1 Data flow

All data sent through the socket changes into a series of byte array. Once the smartphone application is executed, it initiates communication between a server and a socket and its socket operates as an individual thread. In order to receive the necessary data for the server, the smartphone sends a commanding query. Then, the server performs query, insertion, modification, or deleting operations with the sent command. The inserting operation is carried out if a second report matches the violation criteria as described in Table 2. The evidence data is then sent to the traffic warden's PC. The traffic warden's PC checks whether the received data are the actual violation data. The received data are stored on a server and the vehicle owner is notified of the presence of a violation report. Fig. 3 shows the overall data stream.

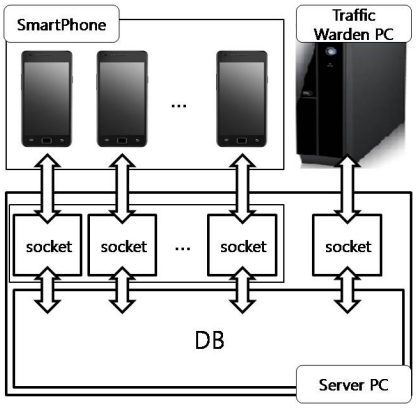

Fig. 3. The overall data stream

3.2 Smartphone activity

The internal process can be made by socket communications. An activity component forms a byte stream to send to a server, data moves to the service area and finally communicates with each other through a socket of service. For requesting data from the server, the activity remains at idle status until the sent data is received. However, if the requested server data were transferred to a service, the activity clears the idle status and uses the service data. Fig. 4 describes the activities on smartphone.

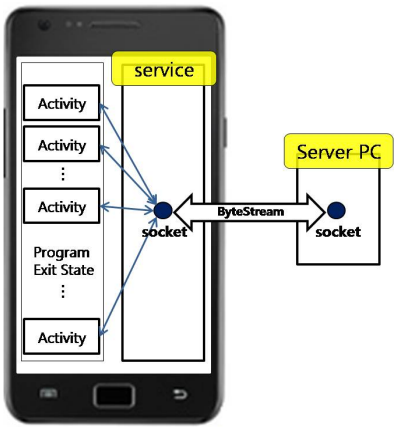

Fig. 4. The Android phone program architecture

3.3 Server – Thread activity

The overall framework is described in Fig. 5. This system involves an external viewer and its internal related data for communicating with the DB. Two threads can be exploited: One is for communicating with the warden PC and the other is for communicating with the general users. The termination of each thread can be recognized by disconnection or application termination.

3.4 Server – Database activity

In our experiment, we used Oracle database with reporting data and registered users as the utilizing tables. If the vehicle has been reported, the vehicle owner's license plate number must be registered with the server for the vehicle owner to be made aware of the violation state. It is possible to register the owner's vehicle by sending a plate picture and the owner's phone number. If the user wants registration, a user needs to fill out information such as the connection socket number, the registrant identification number, vehicle number, phone number, and etc. Since smartphones have registrant identification numbers, a connection socket number can be assigned after checking the registration state.

Reported data are stored in a report table and each record has a cardNum key value generated by analyzing a picture as shown in Fig. 6. When a smartphone receives a violation report, a report record is generated and it is possible to inquire or delete data through the already stored report. In general, the stored record can be used in inquiring.

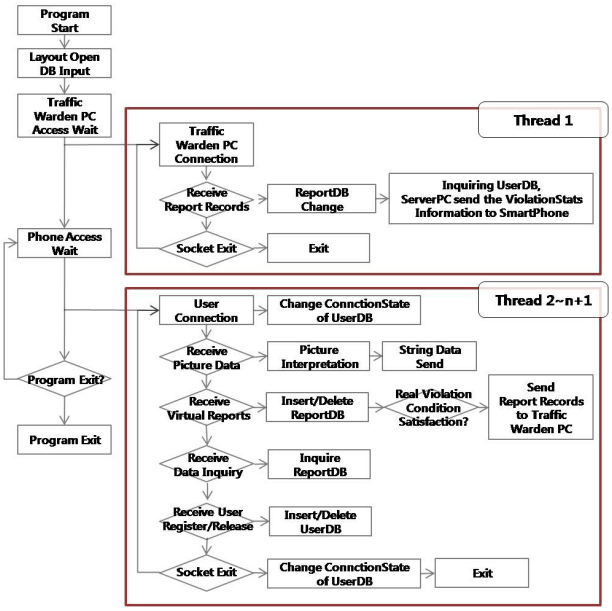

Fig. 5. Description of system program

3.5 Network transmission/receiving packet design

This experiment was designed to transmit or receive data sections simply using JAVA socket class. The first byte of data represents the activity command and the rest of the bytes are used for transformed data. It is not possible to send a picture all at once due to the large volume. Therefore, data can be segmented, transmitted and stored into JPEG image format.

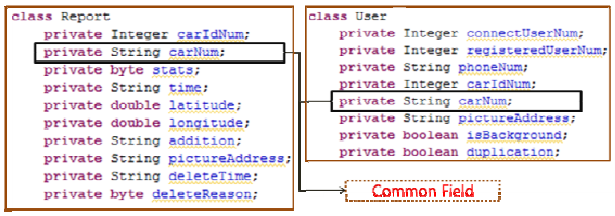

Fig. 6. A class structure

3.6 License Plate Recognition

License plate recognition (LPR), there are many different approaches [21-26]. However, in general, LPR has normal procedures such as recognizing plate area and characters. In our experiment, we use the following procedures:

1. Convert an Image to Gray
2. Mophologial operations
3. Generation histogram on horizontal and vertical direction
4. Thresholding with dynamic values
5. Find ROI and detect characters

4. RESULTS

When the smartphone executed the parking enforcement application, it was connected to a socket of the server; the server manages the registered user list. Using the smartphone's embedded camera, the already registered personnel can take a violation picture and obtained the current location coordinates using the location-based service. The registered personnel then sent the additional information regarding the violation situation and time to the server PC. Due to the large volume of data required for the picture, the data was segmented for transmission. The plate number was analyzed and converted into character strings to be used in the database.

This stored virtual complaint was then compared to the violation criteria to confirm that it was the same vehicle number, the same violation location, and 5 minutes had passed since the first virtual report. In this case, the violation criteria were met. After the warden PC received two more virtual reports, it reviewed the previous violation report and sent the registered user a warning message about the presence of a violation. The registered user then checked the violation status by using his smartphone to access the server.

In this experiment, we used 3 Android phones, one server and one warden PC in a Wi-Fi zone. The next section describes three experiments: concurrent connection, receiving report, and smartphone background experiments.

4.1 Connection experiment

Once the smartphone begins the application program, activity components such as the fore-ground and service components such as the back-ground are connected and socket communication is initiated. On a smartphone, a socket is connected to the server and the server will assign a register ID number. A user registration can be active on only one smartphone and a registered user can check in real time when his car was reported. Fig 7 describes one example for the field

values of Oracle database in communication.

(a)

REGISTEREDUSERNUM	CONNECTUSERNUM	PHONENUM	CARNUM	PICTURE
1	3	2 01077778888	26수3893	20110918211757 62.jpg
2	1	1 01012345555	49가5357	20110918190928812.jpg
3	2	5 01033339898	08무2573	20110918191313703.jpg

(b)

Fig. **7.** (a) Registered user's smartphone screen view (Box indicates plate number) and (b) an example for Oracle database (Box contains phone number, plate number and picture information)

4.2 Receiving a report

In order to report a vehicle in violation, the registered personnel take a picture and obtain the location using the smartphone's location based service. The registered personnel then send the violation information to a server. Fig. 8 shows an example of violation reporting status. For the same vehicle, the same location, and a time difference of more than 5 minutes as shown in Fig. 9, the reporting state depends on Receiving first report, Request report, Receiving second report-approval, or Receiving second report-rejection as described in Table 2.

When a violation report for a registered user's vehicle is received, the background on his smartphone can be warned in real time. Whenever a new report table from the server pc is added, new values are compared with the previously registered records such as the vehicle number, latitude and longitude. If there is more than a 5 minute difference, the record data from the warden PC will be transmitted through a socket to a server. The transmitted data is reviewed one more time on the warden PC before the approval or refusal of the violation report is sent to the server PC. If a violation report is approved on the server PC, the violation vehicle number is searched for on the registered user table. If there is a match, a unique ID is assigned, whether or not his car's violation will be transmitted using a belonging socket.

Since a relating socket through a service component is communicated on a smartphone, a user can receive the presence of a violation report via back-ground activity on a smartphone even though an application program is terminated. Once a violation report has been approved, a user will receive a warning display as shown in Fig. 10.

CarIdNum	CarNum	State	Time	Latitude	Longitude	Addiction	PictureAddr	deleTim
12	07오6572	신고접수완료-거절	2011-09-18 17:02:18	35.899195	128.853567		201109181702...	0000-00-0
13	07오6572	신고접수완료-거절	2011-09-18 17:09:28	35.899117	128.853368		201109181709...	0000-00-0
14	34가2237	실제신고요청	2011-09-18 17:50:13	35.899188	128.853616		201109181750...	0000-00-0
15	78미8808	신고정보수집중	2011-09-18 18:01:02	35.899195	128.853567		201109181801...	0000-00-0
16	34가2237	실제신고요청	2011-09-18 18:06:02	35.899193	128.853978		201109181806...	0000-00-0
17	58나5834	신고정보수집중	2011-09-18 18:35:56	35.899244	128.853697		201109181835...	0000-00-0
18	26수3893	신고접수완료-승인	2011-09-18 21:27:32	35.899193	128.853079		201109182127...	0000-00-0
19	26수3893	신고접수완료-승인	2011-09-18 21:35:56	35.899298	128.853978		201109182135...	0000-00-0
20	17부6904	신고정보수집중	2011-09-19 09:03:53	35.868226	128.699766		201109190912...	0000-00-0

Fig. 8. An example of violation reporting progress using information sent by enforcement officer

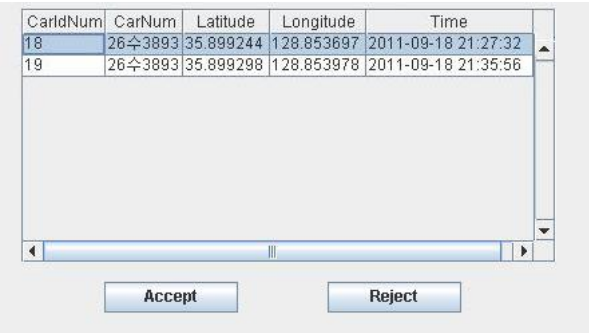

Fig. 9. An example of violation reporting status after 8 minutes using GPS

Fig. 10. Results of screen shots on violation reporting status (Left: Display image, Right: SMS Information.)

5. CONCLUSION

This paper described the development of a smartphone application having high fast development focused on and designed for a real applicable environment. Unlike previous or existing parking enforcement system models, the designed system has pursued a registered personnel complaint reporting system model. This system also utilizes the text warning service to car owner when their car has been processed to violation report. Once this kind of system has been customized, it is possible to enable concurrent access. However, the system needs to protect the users' privacy through encryption of transmitted data, limitations of number of inquiry, and etc.

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Doyeon Kim
He is received the B.S. in computer science from Daegu university, Korea in 2013. He is interested in web intelligence, security and mobile apps.

Jaejoon Kim
He received his B.S. degrees in Mathematics and Electronics Engineering from Hanyang University, Korea in 1988 and 1991. He received his M.S. and Ph.D. degrees in the Department of Electrical Engineering in 1995 and 2000. From 2001 to 2002, he worked for the Electronics and Telecommunications Research Institute (ETRI) in Korea. Currently, he serves as an associate professor at Daegu University. His research interests include multimedia codec, image processing, and nondestructive evaluation.