CROWDSOURCING MODEL FOR REDUCING INAPPROPRIATE PARKING IN URBAN AREAS

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Abstract:
Inappropriately parked vehicles cause inconvenience and threat to many traffic participants. Current ways to solve this problem are slow and inefficient, letting unscrupulous drivers escape without penalties. As a result, number of vehicles that are inappropriately parked increases every day. If we could timely notice inappropriately parked vehicles and inform the authorities promptly, it would be harder for drivers to get away without being fined. Awareness that inappropriate parking would not go unnoticed would impel them to do it more rarely. This paper proposes a design of the new system, based on smartphones and new concepts such as participatory sensing and crowdsourcing, that can timely notice inappropriate parking and inform the responsible ones with the aim to eradicate inappropriate parking.

Keywords:
parking, crowdsourcing, smartphone, participatory sensing.

1. INTRODUCTION

The inappropriate parking of vehicles causes many problems not only to the other drivers but to all traffic participants. Vehicles can be inappropriately parked on different places including the edge of the roads slowing other vehicles and causing traffic jams and congestions, or on the pavements causing inconvenience and threats to pedestrians especially the old and mothers with baby strollers. Beside roads and pavements, there are many areas where parking is strictly forbidden such as: bicycle paths, pedestrian crossings, near railroad crossings, within any tunnel or subway or on any bridge, etc. [1]. If a police officer in charge of traffic control finds inappropriately parked vehicle, they have the authority to order the driver to immediately remove the vehicle under the threat of enforcement [1]. If a driver is absent, the police officer has authority to issue a traffic ticket for the vehicle removal within a period which may not be less than three minutes [1]. As there are not enough police officers to cover the whole urban area, vehicles are parked inappropriately for very long periods of time and very often not fined in any way. If a mechanism that could timely discover inappropriately parked vehicles existed, there would be greater possibility to catch unconscientious drivers. In this way, those drivers would become more aware thus slowly decreasing the number of inappropriately parked vehicles. For all these reasons, there is a

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growing demand for a solution that would enable timely noticing of inappropriately parked vehicles and informing the responsible ones. This paper proposes a solution that would enable timely noticing of inappropriate parking and informing the authorities.

In order to prevent inappropriate vehicle parking in cities, a system which can easily involve a large number of citizens in solving the problem is proposed. To the best of our knowledge, no other researches that solve the problem of inappropriately parked vehicles using the technologies that we use in our research have been conducted.

This paper is organized as follows. Section 2 presents the previous work related to the problem. Section 3 introduces the enabling technologies and concepts. Overall system design is proposed in the Section 4. A case study is represented in the Section 5, while conclusions and future works are given in Section 6.

2. LITERATURE REVIEW

Nowadays, the parking problems have been one of the most discussed topics by the public [2]. Smartphones play an important role in solving the problems related to finding a free parking lot in the big cities. In recent years, many studies indicate that the mobile Internet and the concept of the connected car have advanced at fast pace [3]. The progressive development of ICT has considerable influence on transportation sector; one of the major being parking the vehicle [4]. Furthermore, it is substantiated by an increasing number of mobile crowdsourcing applications allowing users to share information about empty parking lots [5].

Although these researches solve some aspects of the parking problems, problems related to the inappropriately parked vehicles continue to exist. The main problems faced by the municipal parking services are large areas that should be monitored with very low chance that inappropriate parking is fined and improperly parked vehicles are promptly removed. Previous studies indicate the growing importance of smartphones in solving inappropriate parking problem as well as finding free parking lot [2]. The United Kingdom has recently launched crowdsourcing project for reporting inappropriately parked vehicles. Every citizen in UK with the UK Car Park Management (CPM) mobile app can report illegally parked cars anonymously to the CPM by sending a photograph of it. The CPM then uses the number plate to find the driver via the driver vehicle and licensing agency (DVLA) database and sends them a fine. Fined driver would not know if they have been caught by a parking warden or a member of the public [6]. The City of Minneapolis has developed web reporting application [7]. However, further research in this area point out influence of mobile apps and smartphones as devices with embedded high quality cameras that are always connected to the Internet so users can quickly and easily report the problem. Further research must be directed to encourage users to widely use the mobile app. For example, a registered user who reports certain number of inappropriately parked vehicles should be rewarded by decreasing annual fee for their vehicle registration. Moreover, the benefits of mobile app should be notifying the driver of a possible inappropriate parking or stopping, based on the previously removed vehicles from the same location. Users of the app should be able to get a warning to immediately remove the vehicle if it is detected by a submission with the lowest degree of urgency. The usefulness of these ideas reflected in preventive effect on unintentional parking.

3. ENABLING TECHNOLOGIES AND CONCEPTS

The proposed system uses smartphones equipped with GPS sensor and camera, and is based on concepts such as participatory sensing and crowdsourcing. The technology and concepts will be further explained in this section.

Smartphones equipped with GPS sensor and camera

With the increasing number of rich embedded sensors, smartphones are no longer just simple communication devices, but powerful mobile sensor platforms [8] used by more than 2 billion people [9]. They are usually equipped with sensors such as accelerator, gyroscope, proximity sensor, front and back facing camera, GPS, etc. They have become open and programmable devices offering software development kits, APIs and software tools. The combination of these advances enables the development of the new applications across a wide variety of domains, such as healthcare [10], [11], social networks [12], safety, environmental monitoring [13], transportation [14], etc.

The GPS stands for Global Positioning System which was originally developed for the military purposes. GPS sensor allows the phone to be localized with the accuracy within 10 meters enabling a whole new myriad of locations-based applications, such as local search, mobile social networks, navigation etc.

Crowdsourcing and participatory sensing

Participatory sensing represents data collection where the user is actively engaged. Although it can be realized using different devices, "several features of mobile phones make them a special and unprecedented tool for engaging participants in sensing their local environment" [15]. Cellular infrastructure is widespread and a number of smartphone users increases every day enabling collection of huge amount of data generated by smartphone users. This concept is getting more interest in the field of smartphones as it enables diverse possibilities through performing large-scale sensing. Each user can contribute its sensed data using collaborative sensing application. A participatory smartphone sensing system consists of sensing platform and many smartphone users who can send sensed data to the platform using cellular data channels [16]. So far there are many researches devoted to the developing various applications such as: application that uses location data sampled from everyday mobile phones to calculate personalized estimates of environmental impact and exposure [13] or exposure to noise [17], etc.

The term "crowdsourcing" was first introduced by Jeff Howe in 2006 [18] and can be defined as "a type of participative online activity in which an individual, an institution, a non-profit organization, or company proposes to a group of individuals of varying knowledge, heterogeneity, and number, via a flexible open call, the voluntary undertaking of a task" [19]. The crowd participates in the task while the mutual benefit exists both to the crowd participants and the crowdsourcer - the person that initiates crowdsourcing processes [19]. Today there are different non-profit crowdsourcing applications such as Wikipedia [20], OpenStreetMap [21] and commercial ones such as [22], [23], [24]. Crowdsourcing can be used for obtaining information, thus replacing the enormous human and infrastructure resources. It relies exclusively on the smartphones which users already own [5].

Participatory sensing can be combined with crowdsourcing enabling a new way of collecting data that can be used with the aim to enhance quality of life in the urban environments. That integration can be done in the following way: citizens can use smartphone application to gather different data that can be later validated, processed and used by authorized personnel or different communal services.

4. OVERALL SYSTEM DESIGN

The increasing deployment and exploitation of pervasive computing technologies is making our urban environments very rich in terms of sensing, actuating and computing devices. Smartphone equipped with GPS and camera with embedded computational, communication and storage capabilities represents one of them. As it is open and programmable device, different applications can be developed.

Our proposed system should be composed of two smartphone applications: one for the public, and the other should be only available to the authorized personnel.

The first application could be used by public and its main purpose would be to enable capturing of the inappropriately parked vehicles. The application should enable the citizen to take the picture of the inappropriately parked vehicle. Taking a picture should be done manually, while the rest of the data such as their GPS coordinates and accurate time should be automatically determined and uploaded to the server together with the captured picture. The image with GPS coordinates represents a submission made by a citizen. Beside this role, the application should enable different views of resolved and unresolved submissions based on different searches and different distribution of submissions showing the time of the day to pinpoint hours when the number of inappropriately parked vehicles was the highest.

The second application should be used by an authorized person with the aim to determine the validity and priority of the received submission. Only after an authorized person approves/declines pending submission and marks its priority, it should become visible to police officers on the field or any authorized person who is allowed to perform the removal of the vehicles. The application will show the customized ordered list of submissions based on submission priorities and the location of the authorized person. After performing some action, the authorized person should mark the submission as solved and the way it was done. A notification about solved submission should be sent to the citizen automatically. This way the time needed to perceive inappropriately parked vehicle and perform an action such as issuing a fine or physically removing the vehicle, would significantly decrease. The Figure 1 shows the UML collaboration diagram of the proposed system.

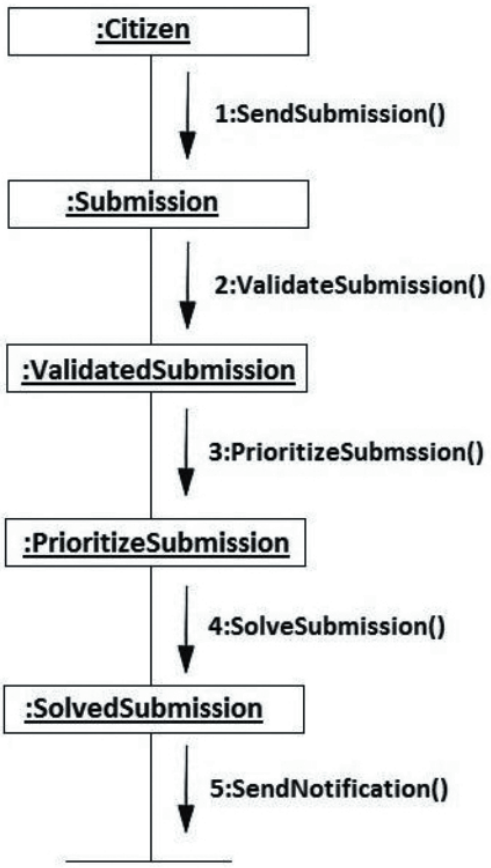

Fig. 1. UML collaboration diagram of a citizen submission

Both applications should be smartphone applications developed for different kind of smartphones (based on Android and iOS) and deployable for every smartphone user, thus enabling greater availability. Different technologies and programming languages should be used: Java can be used for developing Android application while Swift will be used for developing applications for iPhone users. In order to be used by a great number of people, applications must be easy to use, user-friendly and intuitive. Every citizen interested in participation would need to create an account. That would reduce the number of inappropriate submissions. The data should be distributed through different servers to minimize different types of attacks, especially DDoS attacks. Every sent submission will be stored in a relational database, such as mySQL. If we restrict our solution to one big city, we expect that the number of submissions would not be that "big" and that the standard database tools would be enough. To enforce citizen engagement, the application must provide feedbacks to the users – especially for the submissions they sent.

5. AN EXAMPLE SCENARIO

As citizens are moving through city they can produce great loads of data. Many of them are equipped with a smartphone with embedded camera and GPS and it can be used to solve some everyday problems. Anyone interested can use his own device to contribute.

For example, if someone notices inappropriately parked vehicle, they can use previously downloaded application and take a photo of the vehicle adding optional description. Using mobile networks or WIFI, the picture with the person's GPS coordinates and the actual server time would be sent to the server. At the same moment, an authorized person receives notification about new pending submission. They make sure that the picture is valid in terms that it really represents inappropriately parked vehicle and marks its priority. Every police officer on field sees their customized list of submissions that should be solved based on their current location and priority. A police officer reaches the location marked by the submission and solves "the problem" by removing the car or by writing a ticket. After solving the submission, they mark it as solved. The person who reported the problem receives the notification about its status and how it was solved.

The Figure 2 represents the inappropriate parking model with its main points: noticing an inappropriately parked vehicle and making an image using a smartphone application; sending a submission; submission validation; and finally removing the vehicle.

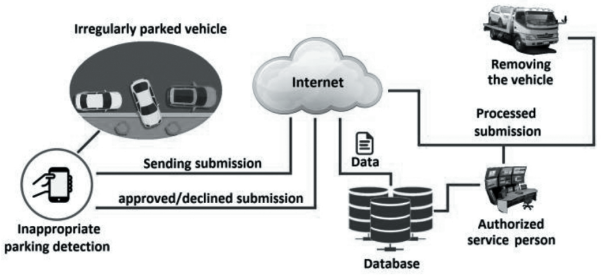

Fig. 2. Inappropriate parking reporting model

6. CONCLUSIONS AND FUTURE WORKS

Recent progress in pervasive computing enables innovative models and applications where a great number of people can be engaged in collaboration with the same aim: to solve problems that would not be able to be solved without the "crowd". Integrating pervasive computing

technologies and crowdsourcing can change our environment in a better way increasing the quality of our lives. Citizens can use their smartphones as data-gathering devices and sensors can be used to sense the environment. Sensors such as camera or GPS embedded in smartphone can be used to develop mobile applications that can be used by a great number of citizens forming a new collective capacity with the aim to make positive influence in their living environment. Data produced by citizens who are interested to improve urban environment can be gathered by using a mobile application. A group of citizens could use their smartphones as a tool to take geotagged images as they move around and create a great amount of data which can be later used to prioritize different maintenance services – in our case to determine the priority of removing inappropriately parked vehicles.

This way a better control over inappropriate parking would be established. This application can be used by communal services to improve their work. It can support more dynamic and effective planning of maintenance activities, and can be a very effective way to make citizens feel as a part of the community. Additionally, data received this way can be thoroughly examined and can be used in making different estimations about different traffic conditions, marking spots with huge parking problems and using received data to calculate routes.

As previously mentioned - this research represents an innovative approach in solving the problem of inappropriately parked vehicles and can be used as a foundation for the comprehensive model that is able to deal with a wide variety of problems that exist in urban areas especially big cities where local services cannot meet the metropolitan challenges they are facing.

The next step would be development of these applications and testing the system in the urban environments. Such a system could be beneficial not only to the local government, but also to great number of citizens. In this model, we have focused on solving parking issues in one big city, but it would be possible to extend it to the whole country or even wider: to the whole world and the issues that can be solved this way are not limited to the parking. This expansion would lead to generating great amounts of heterogeneous data that could not be processed using relational databases and their tools. Therefore, one of our future steps would be to explore the big data and its role in solving different kind of issues by defining different patterns from the collected data and finding the way to use them more efficiently. One of the drawbacks of this approach is related to the quality of data which is dependent on the participant enthusiasm to take an active role.

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