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OFFERING A METHOD TO FIND THE MOST PROPER PARKING SPACE IN THE CITY AUTOMOBILE EXPEDIENCY NETWORK BY GENETIC ALGORITHM

Finding a free space for parking in rush hours and heavy traffic has been always a boring and time-consuming problem for drivers. Recently, VANET networks have found special attention among economists and university researchers. Due to day-by-day expansion of wireless communicative systems, many car manufacturers have been installing such communicative tools as OBU on their products. The RSU tools give drivers the possibility to have better and more convenient means of communication. They can trace the availability of parking spaces using these tools and be guided to there, while the automobiles can be equipped with anti-burglar systems to have a higher security. In this research, a comprehensive method using the genetic algorithm have been offered to find a place for parking in the automobile expediency network, which has considered many parameters such as parking space being located near or far, cost of parking space for drivers, the probability of parking space remaining available until the car arrives and reduced past defects as much as possible.

Keywords: intelligent parking, RSU installations, OBU installation, automobile expediency network, parking condition indicator.

The researches that have been done so far in this field have both their advantages and disadvantages. The advantages points are the possibility to find a parking space in accordance with individual needs using mathematical and statistical methods in the intra-automobile expediency network taking into consideration its disadvantages. Such parameters as the location of parking space (is it far or near), the cost of parking space for driver, the probability of parking space being available upon arrival of the car have been taken into account and remedied disadvantages of previous researches as much as possible [1].

Before designing the system, first we should consider the following hypotheses:

The first hypothesis: TAs are reliable for all OBUs and RSUs.

The second hypothesis: each OBU has private code and drivers before starting should enter their codes. Therefore, not every person can access to data and information in it.

The third hypothesis: the useful reach and distance between RSUs are calculated correctly and the RSUs are installed in proper places.

Our purpose is to design an intelligent parking system. This system will meet the following needs:

1. The least error data error that system suggests to driver.
2. The system is comprehensive and takes into account various parameters such as the location of parking space (far or near), parking fee, the probability of parking space availability upon car arrival.
3. Reliability of obtained information.
4. Use of the best method to publish data for a certain user.

5. Enhanced security and prevention of carjacking.

PROPOSAL

This proposal is based on 3 steps:

1. As soon as a car with OBU installed enters an urban area covered by the intelligent parking management system, the first action is to refer it to cluster r region under control of RSU, and that car is dedicated there.

2. Each vehicle at any time can issue an application for available parking.

3. This application is a message to the other available vehicles of that cluster, and the other transportation systems share the parking condition.

Yet, the driver can do the following actions depending on the parking condition and the time he wants to stay in the parking:

a) depending on the parking condition, a certain suggestion is sent to reserve one of available spaces;

b) depending on the parking condition, a certain suggestion is sent to reserve one of available spaces in a certain time;

c) depending on the parking condition, an uncertain suggestion is sent to reserve one of available spaces;

d) based on driver's selection criteria, the system is required to calculate the best place for parking and to suggest it to the driver.

Applications from other vehicles in the cluster are sent to RSU and then to the intelligent parking management system in order to make decision. Now based on drivers' responses, one of the following responses is sent:

1. If the driver accepts a certain suggestion to reserve one of available parking space, the system reserves the place for him, records duration, puts for that place indicator 1, and publishes the new condition.

2. If the driver certain a certain suggestion to reserve a certain parking space in a certain time, the system calculates that place will be available in the future and publishes a respective report.

3. If the driver accepts uncertain suggestion to reserve one of available parking spaces, the system calculates the probability of parking space availability in the future and publishes a respective report.

If the driver asks the system to calculate the best place according to a certain criterion and to suggest it to him, the system using the goal function, based on the criterions, finds the best place and suggests it to the driver, then activates the indicator of that place, and the new condition is published by sending a respective message to the cars.

Such criterions are accessible for the drivers and the selected goal function tries to have the most influence on choosing a parking space:

- the nearest parking space;
- the cheapest parking space; and
- use of the guide (navigation) system.

The car parking backgrounds are kept in the databank of intelligent management system. This matter can be used to suggest a certain parking place or exploring times series of car parking [4, 8].

PARKING CONDITION INDICATOR

In this structure we try to show parking as follows: each parking space is indicated either with 0 or with 1 (0 for available space and 1 for occupied one). All parking conditions can be identified just by one of the two numbers, which is easily transferrable among the cars.

For example, 0000000 means that the parking is completely empty, while 1111111 means that the parking is completely full. 00010101 means that the places 1, 3, and 5 are occupied, while the others are available. The only shortcoming of this system is the length of numbers for very large parking area, but it can be solved using the hierarchy structure.

Using a 48-byte number, the city parking conditions are showable.

Example:

10101010.11111111.00000000.11001010.
00000001.00000010.

The first 8 bytes are equal to 00001000 and show the number of certain parking area in the city. This is a decimal number that equals to 2 and indicates that this parking area is numbered 2nd in the city.

The second 8 bytes 01000000 are used for hierarchical structure of parking. Here this number shows that there are 32 parking spaces in the parking area No.2.

The third 8 bytes mean 01010110 and show the situation in the first parking line. As it was said before, 0 means that the place is empty and 1 shows that the place is occupied. Here, 01010110 means the places 1, 3, 5, and 6 are empty and the others are occupied.

The fourth 8 bytes mean 00000000 and show the situation in the second parking line. Here, 00000000 means all places from 8 to 15 are empty.

The fifth 8 bytes mean 11111111 and show the situation in the third parking line. Here, 11111111 means that all places from 16 to 23 are full.

The sixth 8 bytes mean 10101010 and show the situation in the fourth parking line of this parking area. Here, 10101010 means that the places 25, 27, 29, and 31 are occupied, whereas the other spaces are available, which is shown by decimal _IP number. The amounts corresponding to the above numbers are 170, 255, 0, 200, 1, and 2, and indicate the available parking spaces in the city. Of course, if necessary, the hierarchical structure can be expanded. These numbers are transferred easily among the cars and RSUs. In order to show the parking condition in a given moment, another parameter, Time Stamp, can be added [3, 4].

SECURITY OF COMMUNICATIONS

Since the car drivers are competing for a proper parking space, there is a risk that some of them change the information content in the course of data transfer. In order to increase information security of OBUs and RSUs and to decrease a risk of unauthorized interference, MAC ID codes are used. The MAC ID code signing ensures the transfer of message that can be confirmed or rejected message safely and checks the sender identity. The MAC code producing algorithm uses a series key agreed between 2 parties and produces a string of bytes called Tag.

OBUs while transferring information send the main message with MAC code to RSU. RSU precisely repeats this procedure. The main message with series key is delivered to algorithm and corresponding MAC code is produced and compared to the MAC code of the message. If this comparison result is positive, firstly, we become sure that message is integral without any modification. Secondly, as no other OBU knows agreed key of the parties, there would be no chance of fake. The best features of this method as compared with other ones are high speed and very short length, so its implementation is possible at both software and hardware levels [4].

One of the MAC code calculation algorithms is well-known HMAC function. In the first step of this algorithm, a series key agreed among parties become linked to the constant ipad with simple XOR structure. The connection results become abstract and are placed at the beginning of message (by the method of SHA-1). Another key time series with constant amount of opad is simplified as XOR and then attached to the beginning of abstract. At the end, it is congested by the mixer function. The result of this congestion is a new abstract that is the same identity code and data safety [4, 11].

```
T_1←Key⊕ipad
T_2←CONCAT(T_1,Message)
H_1←Hash(T_2)
T_3←Key⊕opad
T_4←CONCAT(T_3,H_1)
H_2←Hash(T_4)
Return H_2
```

Can be described as the following semi-code: HMAC

```
ipad←363636....
opad←5c5c5c
```

CRITERIONS TO EVALUATE THE GOAL FUNCTION

When an OBU asks the parking intelligent management system to find a parking place the system should suggest the best and the most proper place according to criterions the driver indicated and use a goal function. Such criterions are:

1. The nearest parking space.
2. The cheapest cost.
3. A fast parking space.
4. Use of guide (navigation) system.
5. Adaptation of places with a high probability of their application in the future.

It is clear that the goal function should have the ability of influencing all or some of the mentioned criterions in the parking space calculations. Below, we try to study how each one influences [7, 8] them.

CALCULATING THE NEAREST PARKING SPACE

In order to calculate the nearest parking space, a set of 2 distances should be obtained:

The Nearest Parking Space When the Car is outside of the Parking Area inside the City

As the discussed system has the ability of parking management for the parking areas, it is necessary to use GPS to determine OBU places in the city. According to the proposed structure; each OBU immediately after its activation and assignment of identity code is recorded in one or several RSU, and its distance criterion as regards the parking area is calculated as follows:

POSO (x_i,y_j): geography condition OBU based on x, y

POSR (X_i, Y_j): geography condition of RSU based on X ,Y

Now, if OBU is at the parking entrance, its Euclidean distance is calculated by the following relationship and the nearest RSU is guided by OBU:

$$Distance = \sqrt{(x_i - X_i)^2 + (y_j - Y_j)^2}\ .$$

Otherwise, if OBU is within the range of RSU, the distance between it and the nearest RSU at the entrance of parking area should be added. It is necessary because RSUs are fixed and consequently each RSU is aware of the distance between itself and other RSUs:

$$Distance_1 = \sqrt{(x_i - X_i)^2 + (y_j - Y_j)^2} + \\ + Distance\ BASE\ RSU.$$

The BASE RSU Distance: the distance from the current RSU to the RSU at the entrance of parking area [9].

The Nearest Parking Space inside the Parking Area

In order to cover the whole parking area, several RSU are used depending on their scope. As a vehicle enters the parking area, based on the driver priorities and goal function results, firstly, RSUs select a proper parking space, and then all RSUs calculate the distance from every one to the vehicle. For example, (D_1, D_2, D_3), the least value Min (D_1, D_2, D_3) is selected among distances; therefore, RSUs can determine the shortest distance between the car and the parking space.

$$Distance_2\ RSU\ 1 = \sqrt{(x_i - P_i)^2 + (y_j - P_j)^2},$$

$$Distance_2\ RSU\ 2 = \sqrt{(x_i - P_i)^2 + (y_j - P_j)^2},$$

$$Distance_2\ RSU\ 3 = \sqrt{(x_i - P_i)^2 + (y_j - P_j)^2}.$$

POSP (P_i, P_j): parking space geographical condition based on i and j:

$$\text{Distance}_2 = \min(\text{Distance}_2\ \text{RSU 1, Distance}_2\ \text{RSU 2, Distance}_2\ \text{RSU 3}).$$

Therefore, the current distance from the carto the parking space is equal to:

$$\text{Distance} = \text{Distance}_1 + \text{Distance}_2.$$

The Probability of a Parking Space Being Available at Time t

The probability of a parking space for the j-th car out of i vehicles is calculated according to the Poisson distribution:

$$P_j = \frac{\sum_{i=1}^{n} \lambda_{p_{ij}}}{\sum_{i=1}^{n} \lambda_i}.$$

In this relation, user applications for parking with the Poisson distribution and λ_i rate are written:

$$f(x) = \frac{\lambda^x e^{-\lambda}}{x!},\ x = 0,1,2, \ldots$$

The possibility of parking for the car upon its arrival in the parking area can be obtained by the following probability:

$$f(x) = \frac{\lambda^x e^{-\lambda}}{x!}.$$

The probability p of available place is:

$$P(X < M) = \sum_{X=0}^{M} P(X = x) =$$
$$= f(0) + f(1) + \cdots + f(M).$$

USING THE GENETIC ALGORITHM TO DETERMINE THE BEST PARKING SPACE

Since there are several criterions such as the distance, the number of available spaces, the probability of available space upon arrival to the parking area, and safety, while determining the best parking space for the car, for each case of the goal function, one criterion is considered:

X1: the distance from the car to the parking space;

X2: the number of available parking spaces;

X3: the probability of, at least, one available parking space upon the car arrival in the parking area;

X4: parking fee; and

X5: carjacking risk.

Fitness Function

According to the stated specifications of the genetic algorithm, the following linear equation can be used to determine the best parking space among the available ones:

$$F = min\,(w_1 X_1 + w_2 X_2 + w_3 X_3 + w_4 X_4 + w_5 X_5).$$

In the above equation, w_i are variable weights.

Genetic Algorithm Parameters

Population size: 100;

Selection operator: based on the contest pattern;

Intersection operator: spinal intersection 0.58;

Jump operator: 0.02;

Generation numbers: 50.

In this research, Ring Cross Over operator has been used, with genes selected just from spinal chromosomes. The determination of the best parking space using GA has the following steps:

Input: the existing parking spaces;

Random production of a collection of solutions;

Fitness calculation values for each solution;

New population by repeating the following steps:

Selecting parents of current population based on fitness;

Using the Ring Cross Over to make a new generation;

Using the jump operator to produce a new child;

Putting the new child in the population;

Using the new population to implement the next algorithm.

If the last condition is met, the algorithm finishes and the best solution for the current population is adapted to the chosen criterions.

In comparison with the existing methods that focus on one criterion only, the stated method can consider combination of various criterions for example, certainty or uncertainty. Besides, the existing methods have this ability only in one parking range, while the mentioned method is easily usable all over the city.

CONCLUSIONS

In this research, the problem of an intelligent system for parking in the city automobile expediency network. The purpose is to design an intelligent system for parking, which is able to calculate and to suggest the best and fastest parking space. A structure how to show the parking condition and to ensure related information transfer using 0 and 1 bytes has been suggested. In this structure, 0 is indicator of available parking space. This structure provides an easy communication among the cars. The policies introduced in this research show various conditions and, finally, the goal function and the current parking lot condition are created among variables selected by the system or by the driver by statistical methods. In comparison with the existing methods that focus on one criterion (for instance, the nearest parking lot) only, the suggested method can take into consideration all stated criteria, certainty or uncertainty, and this is its advantage over other methods. Besides, all mentioned methods can be applied within one parking range, while this method is usable all over the city.

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МЕТОД ЗНАХОДЖЕННЯ НАЙЗРУЧНІШОГО МІСЦЯ ДЛЯ ПАРКУВАННЯ В МІСЬКІЙ МЕРЕЖІ АВТОМОБІЛЬНИХ СТОЯНОК З ВИКОРИСТАННЯМ ГЕНЕТИЧНОГО АЛГОРИТМУ

Пошук вільного місця для стоянки в години пік завжди є проблемою для водіїв. Останнім часом суб'єкти економіки та університети приділяють особливу увагу мережам VANET. Зважаючи на постійний розвиток бездротових комунікаційних систем, чимало виробників автомобілів встановлюють на свою продукцію комунікатори, зокрема такі як, бортові пристрої обробки даних (onboard units, OBU), а придорожні пристрої (roadside units, RSU) забезпечують водіям зручний спосіб комунікації між собою. За допомогою цих інструментів водії можуть відстежувати наявність місць для паркування і маршрут до них. Окрім того, з метою підвищення безпеки вони передбачають встановлення захисних систем проти зламу. У роботі запропоновано комплексний метод на основі генетичного алгоритму для пошуку вільного паркувального місця в міській мережі автостоянок. Зазначений метод враховує значну кількість параметрів, зокрема таких як відстань до стоянки, вартість місця для паркування, ймовірність того, що місце залишиться вільним до прибуття на стоянку, а також передбачає вдосконалення роботи завдяки усуненню попередніх недоліків.

Ключові слова: розумне паркування, придорожні пристрої, бортові прилади обробки даних, мережа автомобільних стоянок, індикатор стану паркувального місця.

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МЕТОД ОПРЕДЕЛЕНИЯ НАИБОЛЕЕ УДОБНОГО МЕСТА ДЛЯ ПАРКОВКИ В ГОРОДСКОЙ СЕТИ АВТОСТОЯНОК С ИСПОЛЬЗОВАНИЕМ ГЕНЕТИЧЕСКОГО АЛГОРИТМА

Поиск свободного места для стоянки в час пик всегда является проблемой для водителей. В последнее время субъекты экономики и университеты уделяют особое внимание сетям VANET. Учитывая постоянное развитие беспроводных коммуникационных систем, значительно количество изготовителей автомобилей устанавливают на свою продукцию коммуникаторы, в частности такие как бортовые устройства обработки данных (onboard units, OBU), а придорожные устройства (roadside units, RSU) обеспечивают водителям удобный способ коммуникации между собой. При помощи этих инструментов водители могут отслеживать наличие места для парковки и маршрут к ним. Кроме того, с целью повышения безопасности они предусматривают установку защитных систем против взлома. В работе предложен комплексный метод для поиска свободного места для парковки в городской сети автостоянок, который использует генетический алгоритм. метод учитывает множество параметров, в частности таких как расстояние до стоянки, стоимость места для парковки, вероятность того, что место останется свободным до прибытия на стоянку, а также предусматривает усовершенствование работы благодаря ликвидации предыдущих недостатков.

Ключевые слова: умная парковка, придорожные устройства, бортовые приборы обработки данных, сеть автомобильных стоянок, индикатор состояния парковочного места.