DEVELOPMENT OF AUTOMATIC PARKING SYSTEM

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I. INTRODUCTION

In big cities, car owners are constantly faced with the problem of parking. Parked on a street of modern big city for drivers, even the most skillful, it is not simple. Typically, the space remaining between the cars so small, that you can squeeze in there only after a long and hard to maneuver with the risk to get damaged. Solve this problem in different ways.

II. EXSISTING APPROACHE TO DEVELOPMENT

Consider several variants for solving this problem.

The first type of systems consists of four ultrasonic sensor, scanning the surrounding space and the computer that processes these signals and look for a suitable parking place. Having found it, the computer takes control of the car itself. The driver, if desired, can control the speed of the car. According to the results of tests, this system has proved very convenient to use.

Leading foreign automakers such as Volvo, Volkswagen, Mersedes-Benz, have released a number of car models equipped with such a system, automatic parking. In Japan and Britain also sold cars Toyota Prius, equipped with similar parking systems Park Assistant [1].

The second type of automated parking systems was proposed by Siemens, the principle of which lies in the fact that the driver found a suitable place to park, got out through the window and pressed a button on the dashboard. Then the fires set on the steering column, electric motor, which controls the computer. To own a car could park in its design, a number of additional elements. The electric motor starts to rotate the steering wheel and the car, skillfully maneuvering smoothly enters into the very narrow space, even in the harshest conditions. The system is equipped with a parking complex network of 16 cameras and radar probes connected to the computer and providing "autonomous" car-round view. Radars recognize the position of the barriers, video cameras also looking for ways to circumvent it and the presence of pits and bumps on the road. All information comes from them on the computer that controls the actuators embedded in the steering, engine management, transmission and brakes. In a computer the size of the vehicle are entered in advance and given them, the computer calculates the value of what you have to turn the steering wheel, and what speed is needed to successfully drive into a free space between other vehicles. Also, radar detectors during maneuvering determine the size of this interval and the distance to the edge of the sidewalk. The advantage of the automatic parking is that it takes place after the landing of passengers and the driver, so the space for opening doors is no longer required, which greatly facilitates the search for a parking space. And this, at least two feet of the reserve area on each side of the car. Upon returning the automobile owner, after the command transmitter, a car and own travels to the place where the driver has landed [2].

With all the convenience, which ensures the system, it also has several shortcomings. First, it is cumbersome, and secondly, consumes a lot of electricity, which requires an increase in battery power, and thirdly, my dear. Today, some automobile companies are working on adapting the invention to their models.

The third type – a system which by voice prompt to the driver where to turn the steering wheel and where to go – forward or backward. If the car park is not well managed by driver inattention, offered another version of the trajectory. One such system was installed on some models of the firm Opel. The effectiveness of such systems was quite low, and therefore sent a survey to exclude a driver from the process of driving a car in the parking lot.

In contrast, someone who can make mistakes when parking in tight spaces, electronics selects the optimal trajectory and speed, which allows your car at the right "pocket" faster than when the car manage people.

This article discusses the automatic parking system, in structure and principle of operation similar to the systems of the first type. However, since the vast majority of companies – the developers of such systems, hiding the implementation details of the algorithm parking, in developing this system was created its own algorithm, considered further in this article.

Unlike the system proposed by Siemens, this system is lower cost. Despite this, it provides higher efficiency compared with systems of the third type, installed on some cars Opel [3]. All that is required to the driver, it drove up to the parking spaces, to include the system and identify with a direction indicator, which side to park your car. This enables the appropriate sensors, which measure the distance. All the information from sensors and analyzes the microcontroller. The peculiarity of this system from the systems of the first type is that with the help of a car can be parked perpendicular to the sidewalk as well as parallel, so in this system, implemented two algorithms for parking.

III. ALGORITHM OF PERPENDICULAR PARKING AND ALGORITHM OF THE FUZZY OUTPUT

The first algorithm parking based on fuzzy logic. Fuzzy logic is widely used in various analytical and management systems. The system calculates two simple algorithms for two angles of rotation of the wheels and, depending on the distance from the point at which to stop the car, calculates the resulting angle of rotation of the wheels, using the Sugeno fuzzy inference algorithm [4].

Formally, the algorithm Sugeno, proposed by Sugeno and Takagi, can be defined as follows.

– Formation of the rule base fuzzy inference systems.

In the base of the rules are only rules of fuzzy productions of the form:

RULE <#>: IF «β1 IS α1» and «β2 IS α2» TO «w = ε1 * α1 + ε2 * ***α2».*** (1)

Here, ε1, ε2-some weights. The value of output variable ***w*** in custody is defined as a real number.

– Fuzzification (the introduction of fuzziness) of input variables. Fuzzification done by finding the values of membership functions for each of the fuzzy sets (terms).

– Aggregation under-condition in the fuzzy rules of productions.

To determine the degree of truth conditions of all rules of fuzzy productions, as a rule, using the logical operation min-conjunction. Those rules, the degree of truth conditions are different from zero, are considered active and used for further calculations.

– Activating under-conclusion in the fuzzy rules of productions.

First, using one of the methods, formulas (2), (3) or (4), there are degrees of truth values of all the conclusions of the rules of fuzzy productions.

min-activation:

$$\mu'(y) = \min(c_i, \mu(y)); \quad (2)$$

prod-activation:

$$\mu'(y) = c_i * \mu(y); \quad (3)$$

average-activation:

$$\mu'(y) = 0.5 * (c_i + \mu(y)), \quad (4)$$

where μ (y) – membership function of a term, which is the value of some output variable wj, given on a universal set of Y.

Second, calculate a conventional (non-fuzzy) values of output variables of each rule. This is done using the formula (1) for the conclusion, in which instead of a1 and a2 substituted values of input variables to the stage of fuzzification. Thus defined set of values C = (c1, c2 ,..., cn) and set of values of output variables W (w1, w2 ,..., wn), where n – the total number of rules in the base rules.

– Accumulation of conclusions of fuzzy rules of productions. In fact, no, since the calculations are carried out with the usual real numbers ***Wj.***

– Defuzzification output variables.

Used a modified version in the form of the method of center of gravity for the one-point sets (5).

$$y = \left(\sum_{i=1}^{n} x_i * \mu(x_i)\right) / \sum_{i=1}^{n} \mu(x_i) \quad , \quad (5)$$

where n – the number of singleton fuzzy sets.

In this system the distance is defined as a linguistic variable "Distance", owned by a term-set consisting of two terms – "Far" and "Near". Fig. 1 shows the membership functions for these terms. Since the concept of "Far" and "Close" are mutually exclusive, then the membership function will be inversely proportional to each other.

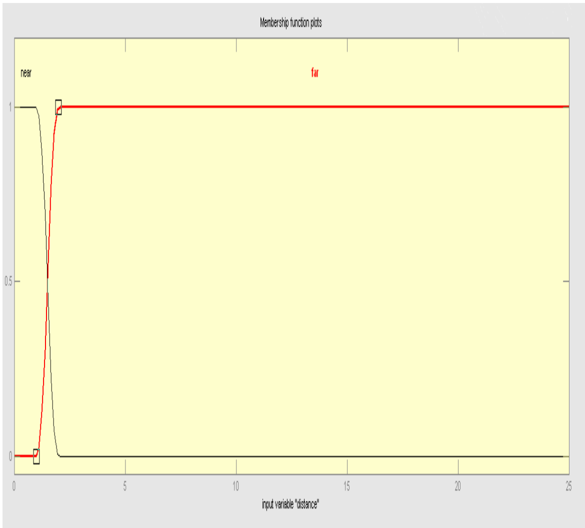

Fig. 1. Membership functions for the terms "far" and "near"

The membership function for the term "near" is defined as a Z-shaped curve (spline function) for the term "far" - in the form of S-shaped curve [5].

Z-shaped and S-shaped curves are described by the following system of equations:

$$f_{Z_2}(x; a, b) = \begin{cases} 1, & x \le a \\ 1 - 2\left(\frac{x-a}{b-a}\right)^2, & a < x \le \frac{a+b}{2} \\ 2\left(\frac{b-x}{b-a}\right)^2, & \frac{a+b}{2} < x < b \\ 0, & b \le x \end{cases}, \quad (6)$$

for Z-shaped curve and

$$f_{S_2}(x;a,b)=\begin{cases} 0, & x \le a \\ 2\left(\frac{x-a}{b-a}\right)^2, & a < x \le \frac{a+b}{2} \\ 1-2\left(\frac{b-x}{b-a}\right)^2, & \frac{a+b}{2} < x < b \\ 1, & b \le x \end{cases}, \quad (7)$$

for the S-shaped curve, where a and b – are real numbers satisfying the inequality a <b.

Base rules for this system is as follows:

"If distance = near, then CORNER1"

"If distance = far, then CORNER2"

"CORNER1" and "CORNER2" – this is the angles of rotation of the wheels, the proposed system, depending on the length of the car relative to the point where he must stop, and the provisions of the longitudinal axis of the vehicle on the plane.

Since this system uses only two terms, the membership function which is inversely proportional, it simplifies the calculations.

First, there is no need to calculate both the degree of membership of the input variable to both the term. Enough to calculate the degree of one of the terms, the degree of belonging to another term will be calculated as follows: μ1 = 1-μ2, where μ2 – the degree of membership of the input variable to another term.

Secondly, at defuzzyfication method (5), drops the fractional part, since it is always equal to unity.

To test this method, was written by the program simulates the operation of the above algorithm. The program has the ability to set the initial conditions, such as coordinates and the position of the vehicle, and vehicle parameters, such as the width of the vehicle, the length of the car, the wheelbase, the maximum angle of rotation of the wheels and the distance from the rear axle to rear bumper.

Fig. 2 shows the results of this program with different initial positions of the car.

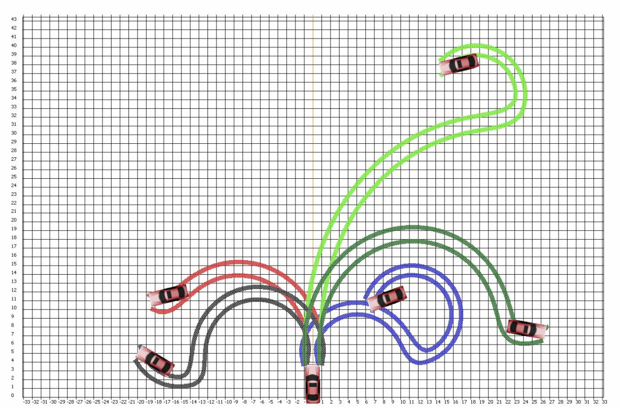

Fig. 2. The result of the demonstration program with perpendicular parking, with different initial conditions

It should be noted that when the driver activates this system, the system begins to operate in a mode of finding the right place, scanning sensors adjacent territory, and as soon as it finds a suitable place, then takes a point of origin (in fig. 2 is a point with coordinates (0, 0)), which will seek to bring the car.

Similarly, when searching for parking space, the system works and in the mode of parallel parking. Yet another method of parking.

IV. NEV ALGORITHM OF PARALLEL PARKING

While parallel parking, as soon as the system finds a suitable place to park is also a point taken as origin, to which the system will strive to bring a car. The coordinates of this point are calculated as follows. Coordinate X, depending on which side should park your car, will take the following values:

X = w / 2 + Δx , if the car should be parked on the left side

X =- (w / 2 + Δx). if the car should be parked on the right side,

where w – is the width of the car, Δx – a constant (the maximum error of the system).

Y = y '+ s + Δy,

where y' – the nearest point of standing behind the car, to standing in front, s – distance from the rear bumper of the car to the rear axle (vehicle overhang), Δy – constant (the maximum error of the system).

The distance between the parked cars that you want to this car parking was geometrically possible, using the following formula:

$$S = ((\min R + w1)^2 + (l-s)^2 - (\max 0, \sqrt{(\min R + W1)^2 + S^2} - W2)^2)^{\frac{1}{2}} + S + \Delta S \quad (8),$$

where S – the shortest distance between parked cars, minR – the smallest turning radius vehicle relative to the center of the rear axle, w1 – the width of the vehicle, l – length of the car, s – overhang car, w2 – width in front of a parked car, ΔS – constant (the maximum error of the system).

When searching for a suitable place to park, according to the formula (8), the system calculates the minimum distance at which the implementation of parking geometrically possible and, when it finds such a place, notify the driver.

Unlike the first mode of the system, here the car parked a few steps.

As with perpendicular parking at the first stage uses the same algorithm to bring the car to a position convenient to carry out follow-up maneuvers. Moreover, if the mode perpendicular to the parking lot was set by a single point, then the parallel parking, depending on the initial position of the car can choose different points, which should bring the car. As soon as the car will be in a particular state, (it will have certain co-ordinates and the position of the longitudinal axis), the system goes to the second phase of parking.

In the second stage, the system calculates the coordinate y, in which you want to twist the wheel and begin direct parking between two cars. If the current y coordinate less than that obtained in the calculations, the system stops parking lot, considering an attempt to park will fail. If the y coordinate greater than estimated, the system continues to show the car to the proper position. If the y coordinate with a certain error satisfies the coordinates, we obtain in the calculations, then the system moves to the next step.

In the third step, the car is twisted wheel at the maximum angle in the right direction, thus ensuring the most efficient path of parking, and monitors the current x coordinate of the car. When reaching, with a given accuracy, some coordinates x, twisted wheel drive vehicle for the maximum angle in the opposite direction.

Fig. 3 and 4 shows the trajectory of the vehicle at different initial conditions.

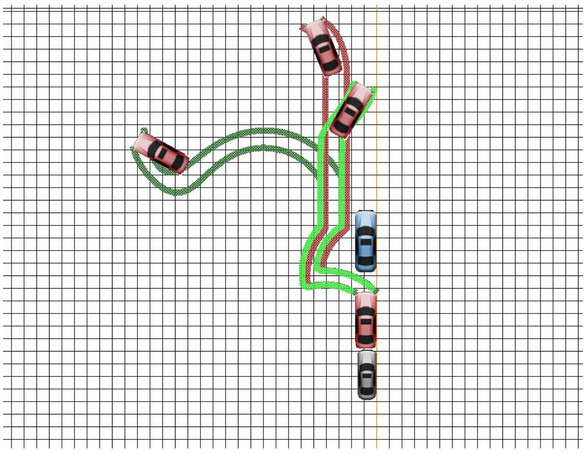

Fig. 3. The result of the demonstration program with parallel parking, with different initial conditions. Parking on the right side

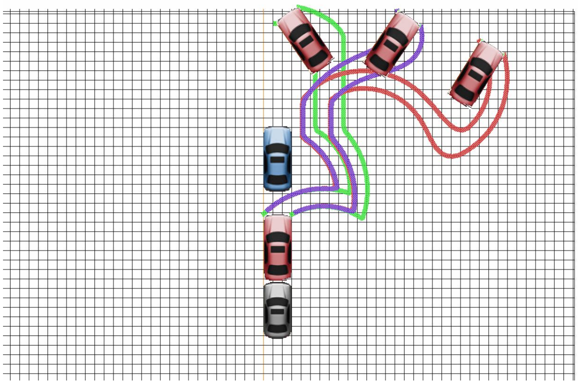

Fig. 4. The result of the demonstration program with parallel parking, with different initial conditions. Parking on the left side

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Should also be noted that when making maneuvers include all sensors. This is done in order to signal the driver of the car approaching to obstacles (similar to PDC).

IV. CONCLUSION

In conclusion, I want to mention one of the advantages of this system. It can be installed on cars of different brands, and not tied to any particular model, in contrast to their counterparts. When the algorithm takes into account the peculiarities of the car. All you need to do - is to install a system to enter the necessary parameters such as: the length of the car, the car's width, wheelbase, maximum angle of rotation of the wheels, the distance from the rear bumper to the rear axle of the car.

Currently the algorithm simulated in software, and is optimizing the trajectory of the car.

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