A car-robot with an automatic parking system

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Abstract

Based on the idea of the new generation of intelligent cars (which require the minimal human interaction possible to fulfill their purpose), a Car-robot with an automatic parking system has been realized, which presents a basic (and perhaps considered a bit idealistic), but suitable alternative of the functionality of an intelligent car (taking into account the limitations of available material and knowledge), by integrating some additional electronic components to it, an specific software and C++ programming [1], in order to make its mechanical functionality smart, more efficient, and more adequate to the current demand of the market (from a simple children's toy to a high-end car). It is designed in order to achieve its goal autonomously by including several different components such as a Controller, Ultrasonic and Micro-switch sensors, etc.

Keywords

Intelligent cars, minimal human interaction, automatic parking system, suitable alternative, electronic components.

1. Introduction

Due to the way this project was created many people can categorized it as a minimalist robotic approach, considering the simplicity of its mechanics design (even though its external design is full of adornments), but this allows us to appreciate the reality of the many examples that we can find today, from a toy car with proximity sensor, to a specialized moving robot, the companies that produce those exemplary products, some of them despite selling the idea of autonomous vehicles, their advertising could not be further from reality, as these do not aim to fulfill the proposed objectives, with the minimum possible human interaction, but simply complete the proposed objective.

On the other hand this project is based on the revolutionary idea that humanity has had since the cars were created [6], which date back to reports from the 20th century of somewhat archaic but crucial tests on the creation of autonomous cars, since experiments such as that of a small Milwaukee company in 1926, being able to control a driverless car through radio waves, gives rise to the seed of autonomic conduction (we can also remark that there are people who affirm that a year before the same experiment was carried out in New York under the supervision of engineer Francis Houdina). As well as in 1939 Norman Bel Geddes presented at the Futurama fair the idea of electric cars driven autonomously through automatic roads, which completely revolutionized the thought of the epoch. Finally, in the 1980s, the German Ernst Dickmanns, who is considered the father of the autonomous vehicle as we know it today, turned a Mercedes-Benz van into an autonomous vehicle guided by an integrated computer, which in 1987 managed to travel the streets without traffic at a speed of 63 km/h [5].

Today, many companies are working every day to develop new technologies to achieve full autonomy, even reaching autonomy levels of 2 or 3 out of 6 (the levels range from a car with assisted steering to an unmanned car), during tests of hundreds of kilometers, such as Mercedes Benz, Tesla, Audi, Cadillac, etc.

2. Purpose and Scope of Work

This project could be an example of the application perspective of the new generations of technology, since it fulfills the contemporary ideology of intelligent cars, at least enough to fulfill the main objective (without being extremely complicate or expensive), which was the possibility of creating a robotic car capable of identifying an available parking area, and apply different driving techniques to achieve ideal parking depending on the available space (all this on a flat surface), based on the above we can distinguish some basic criteria that should be performed correctly [3], such as:

- Be of adequate size to pass through the possible obstacles that could be encountered.
- Have a structure rigid enough to support the electronics components it has, without reaching the point of not being viable for its operation.
- To be able to identify the situation around it.
- To be able to find the correct parameters to execute the right driving technique (vertical or horizontal).
- Be able to operate correctly with minimal human interaction.

3. External Design

In this category we can find the general construction of the robotic car, which is built entirely by more than 150 pieces of LEGO MINDSTORMS' education [7], which make up a basic car skeleton, consisting of 4 side tires, front steering system and rear suspension in the back bumper (and some decorations such as a couple of additional wings, a steering wheel, weapons, etc), in which we can find parts such as Bushings, Axles, Connector pegs, Angular beams, Double angular beams, Frames, Blocks, Springs, Gears, tubes, hubs, tires, panels, etc. In addition to this, as hardware, we have two long Lego NXT motors, a Husarion core 2 processor and 3 ultrasonic sensors HC-SR04 [9], a Micro-switch sensor, plus a Husarion power supply with 3 rechargeable batteries of 3.7V, 12.58Wh and 3400mAh [8], all of them connected by LAN cables. [2]

Figure 1. *Main External Design Components*

4. Prototype Design and Experimental Tests

The basic structure design for this project was elaborated with the objective of creating a structure similar to that of a real sports car (although the most similar would be the formula 1), in other words, sufficiently articulated to be able to move in a controlled space, without achieving a sudden movement. In the overall design, the first thing we can highlight would be the front and rear tires, which have different sizes, the rear tires are larger and wider than the front ones, because these being the ones that provide the main movement to the vehicle, so they need greater stability, and due to the relief design of the same, in addition to having a higher profile (which means that there is more distance between the rim and the ground, so there is much tire volume), allow to provide greater traction with the ground, to ensure a safe movement without turbulence. On the side of the front tires, these not only have a smaller size but also have a lower profile, which provides greater rigidity in its sidewalls, which allows for less wobble and a faster and more precise change of direction. Also, these tires have similar characteristics of a balloon design, which allows to transmit the interaction of the floor with the vehicle in a more effective way (allowing greater traction), in addition to acting as a good suspension element due to its design. At the time of studying the steering systems that have been used over the years, such as Mechanical, Hydraulic, Electric and Electrohydraulic, after studying these mechanisms based on their performance, efficiency and other pros and cons, it was decided that the most suitable for the project would be a mechanical steering system, which initially generated several drawbacks, since reaching a certain angle of rotation, the tires could get stuck and not follow their corresponding direction, and this was because many components were used to transmit the direction of rotation, also the source of this movement (a Lego motor) was not in the same horizontal line as the center of the tire, which produced slight alterations in the accuracy of rotation, either allowing very small angles, or getting stuck in the middle of a turn.

Figure 2. *Tests of structural design*

After many test attempts, it was discovered the way to connect the steering directly to the motor, through a much simpler mechanism, which solved all the problems presented in the mechanical steering system. From this point, the most complicated thing was to create a spring system in the back of the car-robot, that would be able to operate the Micro-switch sensor, which would have the function in any case of error in the spatial identification of the sensors, to recognize any contact with a side wall during parking, and correct the directional trajectory that was planned, with a movement forward and to one side (this movement will depend on the situation presented at any time, as it can be to one side or another), and in this way be able to park in an effective way.

Figure 3. *Back Bumper Sensor*

Finally, all the parts were joined into a base compact and wide enough to support the weight of the controller, the power supply and 2 Ultrasonic sensors on the sides.

During the first parking tests, the main problem that occurred was the reaction of the Lego motors to the information established by the sensors, in other words, the code was not working properly, and this was represented experimentally in how the Car-robot stopped every time the sensors received a proximity alert, it was even thought that the Ultrasonic sensors were defective, because sometimes these measured negative distances of proximity. Fortunately, after a lot of days and many trial and error tests, it was possible to achieve a successful parking, after this the task was much simpler, due to the fact of having a successful test, the only thing to do was to recreate the same conditions in which the Car-robot was able to park the vehicle, and adjust the code parameters to be able to do so regardless of its initial position, and finally to adapt it to the vertical and horizontal parking positions, using the least possible number of movements, depending on the parking technique necessary to carry out the objective correctly.

After a couple of months and many trial and error tests, the Car-robot was able to park vertically and horizontally, but it still had some problems at the time of parking, such as the precision in the movement, because it could enter the parking zone, but it did not have the

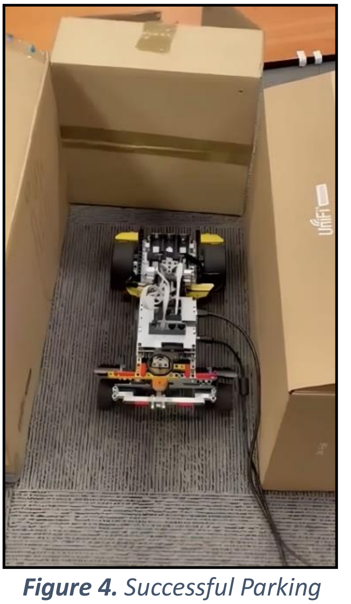

Figure 4. *Successful Parking*

space of the zone correctly distributed, which means that it did not get close to the rear wall, or it was more close to one side of a lateral wall than the other, or it was with a certain angle of inclination to one side. Also it could be observed how the Car-robot became very dependent on the Micro-switch sensor in the rear bumper, because this was used in most of the experimental attempts to avoid colliding with the side walls (and that was not meant to be, the bumper had to be used in an emergency case, where the sensors had a failure in the constant distance measurement with nearby walls), and this was because the sensors did not have correctly set values for the Car-robot's measurements (in other words, the sensors were not aware of the minimum detection or alert range), which forced us to remove the rear bumper, and rewrite the code so that it would be aware of the necessary base measurements (Car-robot measurements) to emit a proximity alert to the motors and be able to change the trajectory during the parking movement.

When the final adjustments were completed to the structural design and the code, experimental parking tests were started again, and finally the Car-robot was able to perform accurate vertical and horizontal parking with a probability of success higher than 95%, without any problems.

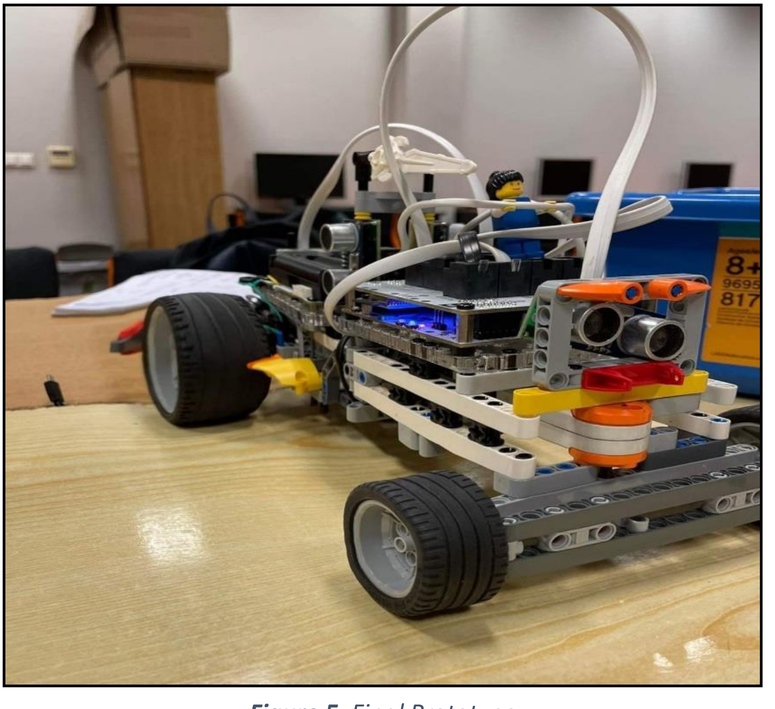

Figure 5. *Final Prototype*

5. Conclusion and Future Work

In this paper has been proposed and realized the idea of a Car-robot capable of identifying an available parking area, and applying the different driving techniques necessary in every situation, to park vertically or horizontally with great accuracy. Based on the contemporary idea that humanity has had since the cars were created, for the new generation of intelligent cars (which require the minimal human interaction possible to fulfill their purpose), without being extremely complicated or expensive, using pieces of Lego and some electronics components such as a Controller and Ultrasonic sensors. Although having fulfilled the main objective, and all the requirements set out in this article, this prototype is still open to improvements, as it presents failures to correct, in addition to various elements or mechanical systems, hardware and software, which can be automatized, in order to make the robot capable of parking under any circumstances or surface (make it an all-terrain robot), such as the steering system, the detection system by sensors (which still has some blind spots, and does not recognize certain objects due to its surface, allowing some collisions with nearby objects), the propulsion system via motors, tires, structural base, etc.

The realization of this project allows to create a precedent in the creation of robots of this type, so that future generations will be able to take as a reference the experiences described in this article, and be able to create an improved version, which fulfills its objectives in completely different situations (whether the car is uphill, downhill, etc), as predecessor generations, contributed as a basis for the realization of this Car-robot.

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