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Development of a Parking Assistance for Model Vehicle

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***Abstract*— A model vehicle has been developed further in order to perform automatic parking. Ultrasonic sensors and STM32 F4 Discovery microcontroller have been mounted. The driving assistant system can find the parking place then parallel parking is performed. The backward motion of the vehicle is carried out along two circular paths, which is followed by corrections of the position and orientation.**

***Keywords*—mechatronics, parking assistant, microcontroller, ultrasonic sensor, autonomous vehicle**

I. Introduction

This paper deals with the further development of a model vehicle to perform automatic parking. Nowadays the driver assistant systems are widely used in high-class cars and also in middle-class ones, which can prevent the accidents [1] – [9].

Path of vehicle can be planed utilizing its kinematics. Due to its sizes microcontrollers are easy mountable on model vehicle. The main controller of the vehicle under development is an STM32F4 Discovery microcontroller [13] - [14]. Ultrasonic sensors, electronic speed controller (ESC) and steering servo have been mounted [10] - [12]. The program of the driving assistant has been written in C language using [15] - [19]. The autonomous vehicle can find the parking place then it moves along two circular arches in backward. Corrections are performed automatically, i.e., achieving parallel orientation and finding middle position.

II. Kinematics of Parallel Parking

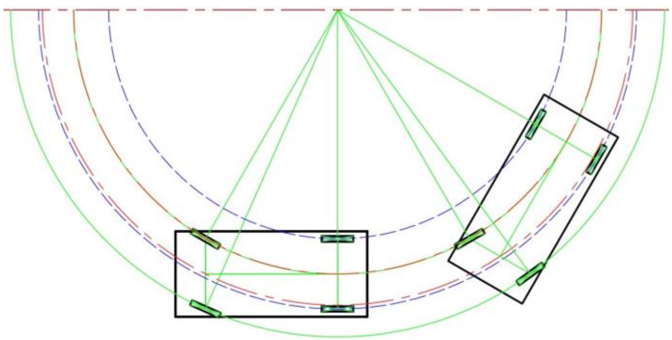

Fig. 1. Limited movement of vehicle

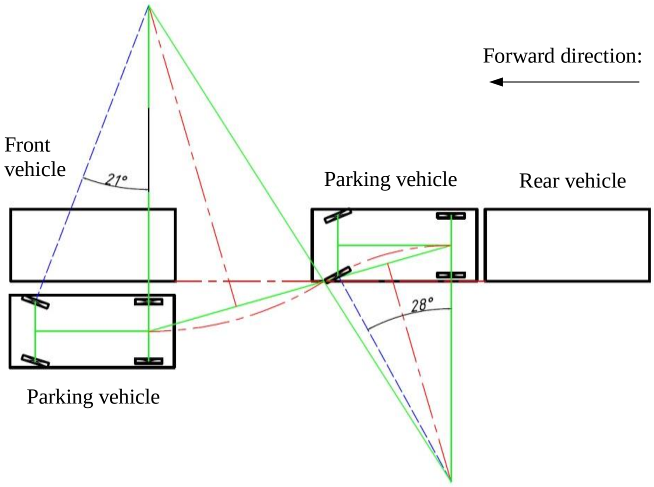

Fig. 2. Planning of path based on movement of rear axis

The vehicle can move along designed path. Due to nonholonomic constraints the motion of the vehicle is determined by the planes of the wheels in ideal cases. A circular path is shown with constant 30° steering angle in Figure 1. The planned parking path, which consists of two arches, is illustrated in Figure 2.

Geometrical sketches are needed for the path planning. Between the middle points of rear axis has been drawn a straight line. The parking involves two arches having opposite curvatures, and the joint point of two arches is determined in the planning process. The best location for this joint point is situated on the side line of the parked vehicle. The angle of steering wheels along the arches can be obtained using triangles (see Figure 2).

The parking involves the following 4 steps:

- Finding parking place and stopping near the front vehicle
- Backward movements along two arches, approaching rear vehicle
- Parallel correction
- Finding middle position

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III. Units for further development the model vehicle

The original model vehicle is commercially available, which can be seen in Figure 3 before further development.

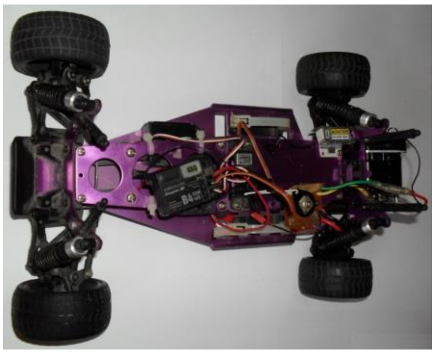

Fig. 3. The model vehicle before development

The original motor controller was a mechanical speed controller, which cannot be applied for slow motion. Therefore an electronic speed controller (ESC) type Reely ESC 420 has been mounted, which can be seen in Figure 4.

Fig. 4. Electronic Speed Controller (ESC)

An electric motor with higher nominal voltage, higher motor turns and lower no-load speed is better applicable for slow motions. A Graupner Speed 500E DC motor was mounted in the vehicle, which has 12V nominal voltage and 12000 1/min no-load speed (Figure 5).

Fig. 5. Graupner Speed 500E DC motor

The electronic system of car is supplied by LiPo accumulator (LRP brand 4600 Hyper Pack type), it is preferable due to its very low self-charge and high-capacity (see Figure 6).

Fig. 6. 4600mAh Capacity, LiPo type accumulator

An ultrasonic sensor is used for sensing of environment. Due to price four HC-SR04 type ultrasonic sensors (Figure 7) have been mounted on the front, on the rear and on the side of car.

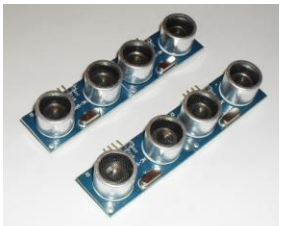

Fig. 7. HC-SR04 Ultrasonic sensors

The brain of the electronic system is a STM32 F4 Discovery type microcontroller, which can handle the signals of sensors as inputs and can control the ESC and steering servo as outputs. The microcontroller has an ARM based CPU, and it is illustrated in Figure 8.

Fig. 8. STM32 F4 Discovery microcontroller

IV. Programming

The steering servo and the ESC can be controlled by PWM signals. Before implementation the necessary PWM signal was tested with an RC (Radio-Controlled) system, the measured values are displayed on an oscilloscope shown in Figure 9. The distance between two pulses is 20ms, so the PWM signal is 50Hz.

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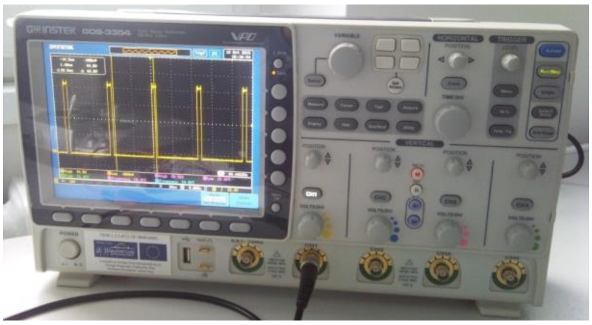
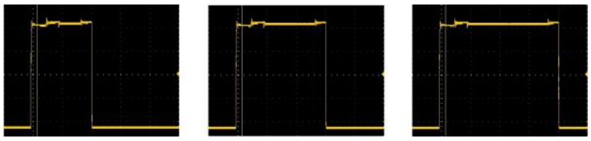


Fig. 9. The PWM signal on oscilloscope for servo or ESC

The width of a pulse can be changed between 1 and 2 ms, which are referring to the right and left steering angles. The zero steering angle is at 1.5 ms when the vehicle is moving along a straight line. The pulses and the steering angles are illustrated in Figure 10 and Figure 11, respectively.



1ms 1.5ms 2ms

Fig. 10. Servo middle- and far positions

(a) Left steering (b) Middle steering (c) Right steering

Fig. 11. Steering servo angles

When the driving motor is also controlled by pulse 1ms, 1.5ms and 2ms, the vehicle is in backward motion, stopped, and forward motion, respectively.

The ultrasonic sensors work with the following I/O signals:

- The input of sensor signal: 10μs TTL trigger signal
- The output of sensor signal: TTL PWL signal (5V->0V)

The flow chart of parallel parking can be seen in Figure 12. In the first step the microcontroller checks the correct measurement of sensors. When any sensor is incorrect, or measures too big distance, the parking will not start. If the parking has been started, the car searches free parking place, then moves near the front vehicle. If the car has arrived near the front vehicle, it starts to move backward along two arches, shown in Figure 2. A parallel orientation correction is needed close to rear vehicle. If the car is in parallel orientation, the microcontroller finds middle position, and if it is necessary, the car will move to middle position.

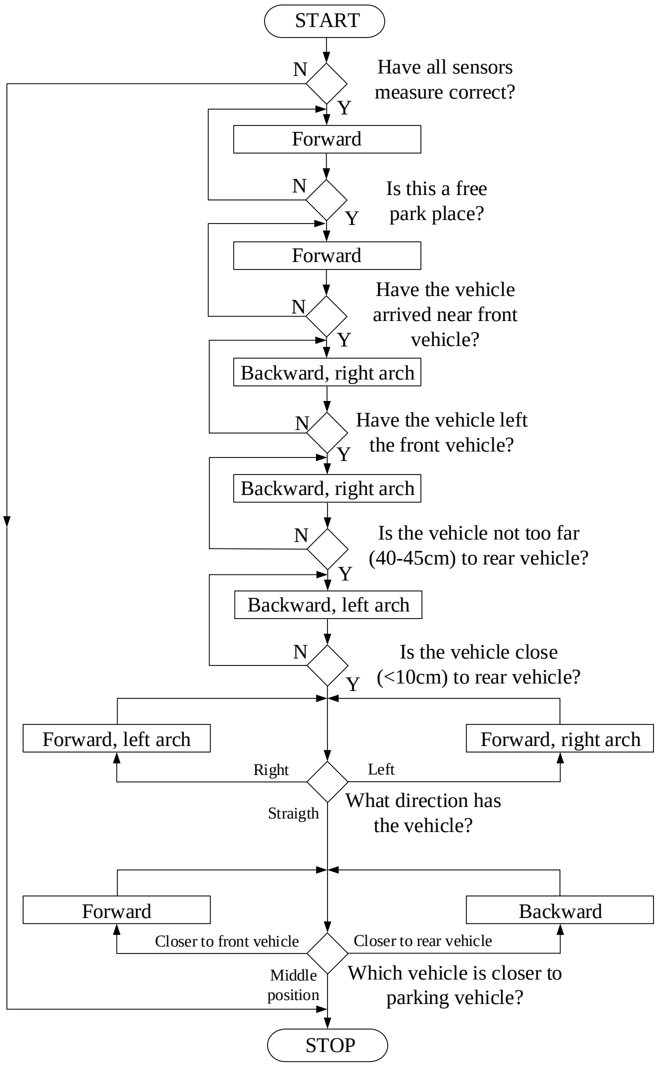


Fig. 12. The flow chart of parking

V. RESULTS

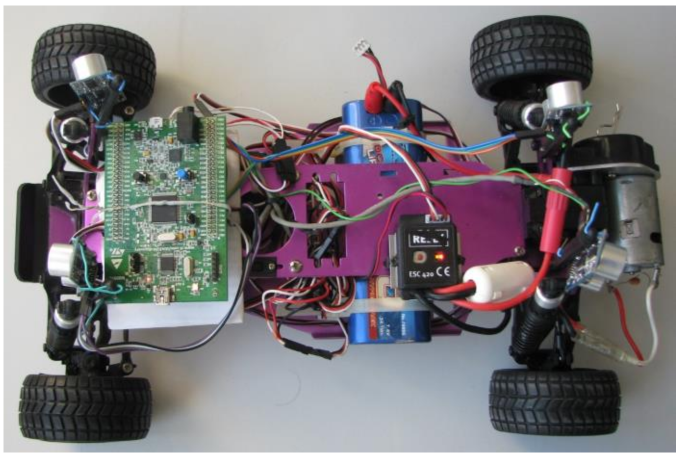


Fig. 13. The autonomous vehicle

The autonomous vehicle can be seen in Figure 13. The steps of parking are illustrated in Figure 14.

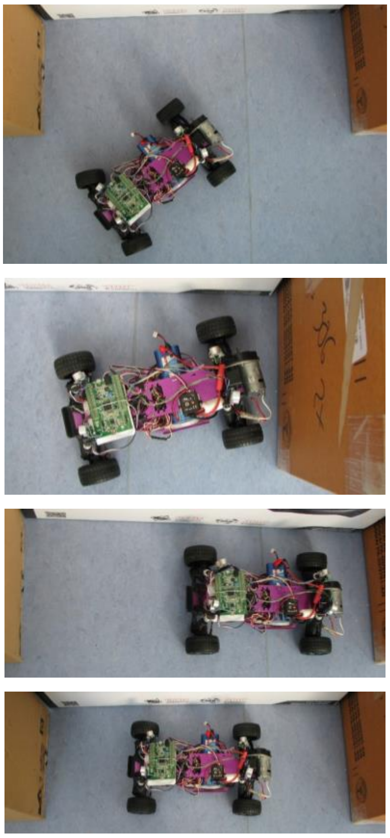


Fig. 14. The last 3 steps of parking

VI. Conclusions

A model vehicle has been developed further in order to perform automatic parking. The STM32F4 Discovery microcontroller, the ultrasonic sensors, the electronic speed controller (ESC) and the steering servo can control the motions of vehicle automatically. The path of vehicle was planned using kinematics of the parking model vehicle.

The present parking assistant systems can be developed further for perpendicular or in garage parking. Other driver assistant systems, e.g. lane follower, adaptive cruise control development are also planned.

Acknowledgement

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