AGV of Mechanical Auxiliary Parking Based on Self Driving

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Abstract. In order to solve the problem of parking difficulties in urban residential areas, a small auxiliary parking device is proposed. Starting from solving the social pain points such as unreasonable parking space planning, residents' random parking, and reducing parking difficulty, it achieves the effect of assisting parking space planning and reducing parking difficulty. The device mainly provides power through the motor, and drives the drum to realize binary control by controlling the steering wheel of the vehicle owner, that is, controlling the switching of the whole movement, and the switching of the front back and left right of the control device. By pressing the spring switch on the wheel, the front control motor drives the gear clutch device to complete the bidirectional switching from left and right movement to back and forth movement. Through the shear fork supporting mechanism and separate self-locking slide rail, the car is lifted and the parking device is driven away.

1. Introduction
With the continuous development of China's social economy, people's purchasing power is gradually enhanced, and the demand for cars is also increasing. According to the statistics of China's motor vehicle ownership released by the Ministry of public security, as of 2016, China's motor vehicle ownership has reached 290 million, of which the total number of vehicles has reached 194 million, and there is a trend of continuous growth. According to the relevant data of the national development and Reform Commission, at present, the proportion of cars and parking spaces in China's big cities is about 1:0.8, while that of developed countries is about 1:1.3. It is conservatively estimated that by 2016, there are more than 50 million parking spaces in China.

In view of the existing parking problem, we take the existing urban residential parking problem as the breakthrough point to carry out research and make targeted improvement. According to our investigation and visit, the existing urban residential car parking modes mainly include three types: oblique, parallel and vertical. Among them, the parallel parking space is narrow and long, and it is widely used in the roadside and some temporary parking places in the community, which accounts for a large proportion of parking spaces in the community. However, there are still many unreasonable places in the existing parallel parking spaces, which aggravate the problem of parking in urban districts.

The existing auxiliary parking device is mainly AGV car, but since the AGV car entered the market, its market scale and development speed are lower than people's expectation. The reason is that the construction of AGV car, long planning cycle, single operation mode, high project operation price, can not be effectively promoted in a short time.
2. Research meaning
Aiming at the problem of parking difficulty in the existing urban community, taking the defects of parallel parking space as the breakthrough point, starting from the common problems such as reasonable planning of parking space, standardizing parking mode and reducing the difficulty of parallel parking, a small auxiliary parking device is designed, which can not only realize the expected function, but also has the advantages of simple control and low cost compared with AGV car. The device is mainly used to realize two functions. 1. Assist the owner to complete side parking. The average time of side direction parallel parking is more than 2 minutes, and the parking time is shortened to 30 seconds after using the device. 2. Auxiliary standard parking. After using the device, the community property can use this device to adjust the non-standard parking mode in the community, solve the problems of multiple parking spaces, body not straightened and other non-standard parking problems in the community, so as to free up more parking spaces and ease the parking difficulties caused by less parking spaces.

3. Conceptual design
3.1. Overall design
In view of the shortage of parallel parking spaces, a small auxiliary parking device is designed to assist manual side parking, and can also be used to assist standard parking in community. Small auxiliary parking device is mainly composed of mechanical structure and control system. The mechanical structure part mainly completes the front and rear limit protection, the device parking movement execution and the separation and restoration of the car. The control of the main steering motion is separated from the steering control. The overall diagram of the device is as follows:

![Figure 1. overall diagram of the device](image)
Table 1. brief introduction of car auxiliary parking device

| modular                                      | Main institutions                                      | Corresponding function                                                                 |
|----------------------------------------------|-------------------------------------------------------|----------------------------------------------------------------------------------------|
| Power source transmission and transmission module | Spur gear set, bevel gear set                          | The spur gear realizes the motion deceleration and transmission; the bevel gear realizes the vertical change of movement direction. |
| Motion execution module                      | Gear clutch, center drive wheel, balance steering wheel | Gear clutch complete movement from left and right to front and back, the center drive wheel drives the whole device to move, balance the steering wheel to make the movement stable. |
| Limit module                                 | Limit baffle, linkage mechanism, rack ratchet mechanism | The limit module ensures the safety of the car owner to access the vehicle. The limiting gear prevents the car from leaving. The linkage mechanism and rack ratchet mechanism adjust the position of the limit plate. |
| Separation module                            | Shear fork mechanism, separating slide rail and cable closing mechanism | The scissor mechanism completes the jacking and lowering of the vehicle, the separation slide rail completes the separation of the self powered part of the shear fork mechanism when lifting the vehicle, and the assembly of the scissors mechanism after lowering; the locking mechanism realizes the fixation of the device. |

3.2. Mechanical structure design

3.2.1. Power source and transmission module. The motion power of the small auxiliary parking device is provided by the motor, and the power is transmitted to its fixed gear through the motor. The power transmission of the two sets of transmission chains is completed by the cooperation of spur gear and bevel gear, respectively corresponding to the left and right movement and the back and forth movement. The schematic diagram of the two sets of transmission chains is as follows. Because gear transmission has the advantages of transmission preparation, small loss and smooth movement, the main application mechanism in transmission module is gear.

![Figure 2. model diagram of integral transmission chain](image)

3.2.2. Motion execution module. The power of the small auxiliary parking device is transmitted from the motor input through the transmission module, and finally acts on the motion execution module to realize the parallel parking motion and forward and backward linear motion of the whole device. The
motion actuator is mainly selected as the universal heavy-duty roller and its supporting device. According to its realization function, it mainly consists of three parts. The power is output by the central driving roller which is concentric with the end shaft of the transmission chain; the steering control wheel is synchronized with the central drive wheel to control friction and avoid the disorder of the device movement; the universal casters installed on the left and right sides of the parking device are mainly used for dispersion Load bearing, reduce the loss of driving wheel and steering control wheel directly installed at the end of transmission chain, and prolong the service life of the whole device. Heavy duty roller is mainly composed of cast iron, which has strong bearing capacity, outstanding impact resistance, wear resistance and long service life.

3.2.3. Centre drive wheel. The central driving wheel mainly completes the power output and carries the movement of the whole parking device. Its movement direction is mainly left and right parking movement and front and rear linear drive. The Centre drive wheel and its main components are shown in the figure below.

![Figure 3. model of centre driving wheel](image)

3.2.4. Motion reversing module. The front and rear direction of the car is mainly controlled by the front and rear direction reversing device, which is mainly controlled by the front and rear parking motor and the main driving device is the right and left clutch. When the parking device needs to complete the reversing movement between the front and rear - left and right, the motor controls the gear clutch mechanism movement to complete the reversing control.

3.2.5. Shear fork supporting mechanism. The shear fork supporting mechanism mainly completes the lifting and descending action of the car after the parallel parking device is moved left and right. Its main structure is composed of motor, lead screw, roller, shear fork beam and supporting plate. Its working principle is that the motor drives the screw to rotate, so that the slider moves and the roller slides on the supporting plate, so that the shear fork beam can lift up or down the supporting plate, and the car can be lifted and lowered.

![Figure 4. model diagram of shear fork supporting mechanism](image)
3.2.6. Limit module. Since the car park on the small auxiliary parking device, the owner is easy to rush out or back out of the parking device due to operational errors. Therefore, a limit module is designed to ensure the safety of the owner and the car.

3.3. Control system design
The control part of the main shear gear is composed of 51 single-chip microcomputer, and the control part of the gear is controlled by a single-chip microcomputer.

4. Calculation and verification

4.1. Overall dimensional planning
First determine the basic size of the device. The basic function of parking device is based on its area can accommodate a car. Referring to the size of standard parking space, 5000mm × 2500mm is selected. Considering the slope, the device area is designed as 4000mm × 2500mm. Because the device has a certain height, in order to achieve the purpose of smooth driving, we use the roller with the smallest diameter as possible, and design the height of the device as 300 mm.

Since there are slopes on both sides of the device to help the car enter, pits will be generated when the two devices are closely arranged. In order to minimize the discomfort of the owners and minimize the gap between the two devices, the slope angle is set at 30 degrees and the overall height of the device is 300 mm. Then the slope length is 510mm, and the overall length of the device is 5000mm.

To sum up, the overall size of the device is 5000mm × 2000mm × 300mm.

4.2. Reverse wheel calculation verification
The force analysis is carried out with the wheel resting between two rollers, and the stress diagram is as follows:

![Figure 5. stress analysis diagram](image)

It is proposed that the diameter of the friction drum in the actual product is designed to be 200 mm, and the shaft spacing between the two rollers is 420mm. The wheel diameter is generally 600-800mm according to the actual body size, and the value here is 640mm. At this time, an equilateral triangle with a side length of 420mm is formed by taking the centre of the automobile wheel and the centre of the two friction rollers as three vertices.

Referring to the existing automobile design standards, the general weight of the vehicle ranges from 1.5T to 2.0T. Taking the 1.5T ordinary vehicle as an example, combined with the actual product of the device, g = 2.0T. According to the general distribution table of rolling friction system, the rolling friction coefficient is generally 0.018-0.020 in the general asphalt or concrete route, and the diameter of the driving wheel in the preliminary design centre is 100 mm.
\[ f = 0.020 \times G_{close} = 400N \]  

\[ T_{roller} = T_{output} = 400N \times 0.1m = 40N \cdot m (\text{Ideal transmission without energy loss}) \]  

So the last contact with the wheel: \( f_{roller} = \frac{T}{r} = 400N \)

Therefore, if the car can not slip between the two friction rollers and drive out of the parking device in the reverse state, then the wheel will not contact the roller 2

So in the vertical direction: \( F_1 \times \sin 60^\circ + F_{roller} \times \cos 60^\circ = \frac{G}{4} = 3750N \)

One of which \( F_{roller} = \frac{T}{r} = 400N; \ F_1 = \frac{7100}{\sqrt{3}} \approx 4100N \)

Horizontally: \( F_1 \times \cos 60^\circ \gg F_{roller} \times \sin 60^\circ \)

Therefore, the friction provided by the friction roller when the wheel is reversed can not meet the need of the car to retreat. The original assumption is not tenable, that is, the car is kept between the two friction rollers when the wheel is reversed, and the body and parking device will not move relative to each other.

5. Conclusion

This device can effectively regulate the parking space in many urban communities, improve the efficiency of space utilization, and alleviate the parking problem of existing urban communities to a certain extent.

At the same time, the device greatly reduces the operation difficulty of the owner when parking in the side direction. At the same time, the self powered and adaptable design can be used to quickly build a temporary parking lot in the open space, so as to solve the parking planning problem of temporary large-scale activities. Greatly improve the efficiency of parking space planning, car access efficiency, ease the parking problem.

In conclusion, the small auxiliary parking device has a broad application prospect.

Acknowledgments

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