Design and Research of Stereo Garage Elevating and Moving Non-motor Vehicle Transversely on Intelligent Control

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Abstract *— In view of the growing city community residents, and their increasing demands for the use of non-motor vehicles, an intelligent non-motor vehicle parking garage system, leaning on highrise building without taking up underground space, is proposed in this paper. The garage adopts closed frame, and transports non-motor vehicles through vertical slider. The experiments show that three-dimensional garage can deliver non-motor vehicles conveniently and accurately in high-speed. The garage can effectively solve the problems of parking non-motor vehicles everywhere disorderly, large proportion of non-motor vehicles garage and low land use ratio in residential districts.*

Keywords *— Non-motor vehicles, Intelligent stereo Garage, Vertical Slider*

I. INTRODUCTION

As we all know, China is the kingdom of bicycles in the world. Bicycles have always been very popular as a green and environmentally friendly means of transportation. Nowadays, various types of non-motor vehicles emerge in an endless stream. With the rising of urban residential areas, demands for the use of non-motor vehicles also increases.

Currently, most of non-motor vehicles parking devices use underground space, such as hydraulic elevator stereo garage built in the cylindrical structure under the ground with the hydraulic pump station as the source of power. The lifting height is limited by the length of the hydraulic cylinder, only applying to the device under 35 meters. Nevertheless, the cylindrical structure in the district covers a large area, and most of the underground space is used to park vehicles, which leads to nervous underground space[1]. On the other hand, the fixed pile bicycle station stereo garage has double layers covering less area. The garage is not closed all around and can only make the vehicle laid neatly, which cannot reduce depreciation rates. Bicycle parking sheds can set up parking racks, which have simple structure and low cost. But the sheds cover large area, and cannot be parked for a long time, while the shed roof is easy to damage and need regular maintenance[2].

Since the mid-1950s, Japan started the garage researches. In 1960, Japan built a four parking positions and the second type three-dimensional garage, and developed self-propelled assembly stereo garage in 1971. In 2010, underground bicycle parking tower ECO designed by Giken can hold 204 bicycles and has high operational efficiency, which can pick up the bike by swiping the card in 12 seconds [2].

China began to develop and use three-dimensional garages in the early 1980s. By the end of 2003, 56 cities of 31 provinces have built 879 three-dimensional garages with more than 80,000 parking positions, half of which are used for supporting facilities in residential communities. Although the car has entered more and more household, bicycles instead substitutes car most of the time. Bicycle parking and space occupation have become a big problem in China[3].

At present most of the parking devices are intelligent in varying degrees to pick up and store vehicles, such as using non-contact smart IC card, using the face, fingerprints, or image contrast, and by computer control[4].

II. STRUCTURAL DESIGN OF NON-MOTOR VEHICLE STEREO GARAGE

A. Overall Structure

The overall structure of the three-dimensional non-motor vehicle garage is shown in Fig.1. Firstly, it includes the garage frame attached to the side wall of the building, parking unit and moving unit.

The garage adopts a closed frame. A number of parking units are arranged in garage frame and distributed horizontally on frame side wall. In this garage structure, the moving unit is located in the middle line of the garage and communicated with the mobile controller, while several parking units are symmetrically set up on both sides.

The design is based on the outer wall of buildings in old residential areas. The size of garage frame changes with the original buildings. The three-dimensional non-motor vehicle garage is introduced in this paper taking a residential district as an example. In this example, the garage frame is attached to the outer side wall of the existing building, and the plane width occupied outwards is about 1.5m~2m[5].

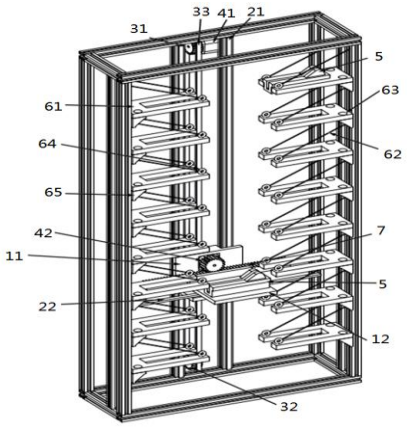

Fig.1 Stereo structure of non-motor vehicle garage

B. Parking Units and Moving Units of Non-motor Vehicles

The moving blocks shown in Fig.2 and Fig.3 are designed in order to solve the problem of different distances between front and rear wheel of various non-motor vehicles. An elongated T-shaped block is set up in the middle of the moving plug block for fixing non-motor vehicle. In this case, the upper part of the T-shaped block along the wall is about 100~120mm longer than the lower part. The width of the lower part of the T-shaped block is the same as the U-shaped slot, while the depth of the lower part is 100mm larger than the thickness of the U-shaped groove.

In order to better park non-motor vehicles, one end of the moving plug block is provided with a fixed front baffle, which is used to maintain stability in the process of transportation up and down. For improving the bearing capacity of the U-groove when the weight of the non-motor vehicle needs to be parked is too high, the side wall of the U-groove away from garage frame is connected to one end of the side wall of the by two lifting rings.

Moving unit consists of vertical guide rail, vertical transmission mechanism, vertical transport platform, horizontal guide rail, horizontal transmission mechanism and horizontal transport platform. The horizontal transmission mechanism can slide along the horizontal guide rail are set up on the vertical transport platform. The vertical transport platform connected to the vertical transmission mechanism can slide along the vertical guide rail, while the horizontal transport platform connected to the horizontal transmission mechanism can slide along the horizontal guide rail. The horizontal transport platform is formed by two plates connected at right angles protruding outwards about 1~1.5m. The protruding horizontal plates are used for placing the moving blocks.

The vertical transmission mechanism includes vertical motor, driving wheel, slave wheel and transmission belt. The horizontal drive mechanism includes horizontal motor and rack[6].

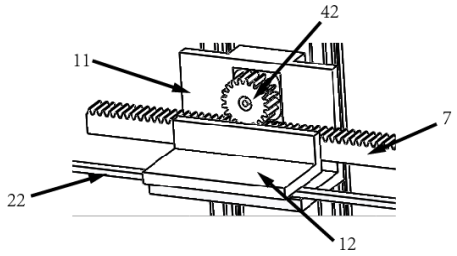

Fig.2 Moving units

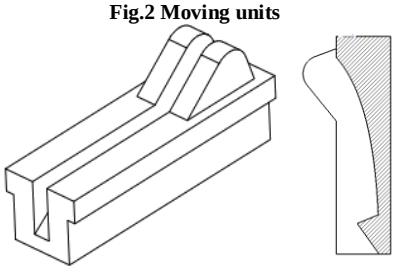

Fig.3 Parking unit

III. DESIGN DETAIL

The operating steps of non-motor vehicle stereo garage are shown following:

1) After the intelligent controller receives the storage instruction, the moving unit through control moves vertically to the set-up position below the empty parking space, whose distance can be set to 120mm;

2) The moving unit moves horizontally, and make the moving block 5 located above the moving unit. Make sure the moving unit completely covers the moving block 5;

3) The moving unit rises vertically, and make the moving block 5 separated from the U-shaped slot 61. Then place the moving block 5 on the moving unit;

4) The moving unit drives the moving plug block 5 to move horizontally first, and then descend vertically to the ground;

5) Place the non-motor vehicle on the moving block 5;

6) The moving unit rises vertically to the empty parking position in step 1;

7) The moving unit moves horizontally, and the moving block 5 slides along the U-shaped slot 61;

8) The moving unit drops vertically, and make the moving block 5 separated from the moving unit and stuck into the U-shaped slot 61, to complete the storage of non-motor vehicles[7].

The process of parking and picking up the bicycle is shown in figure 4. It is mainly divided into parking process, pick-up process and adjustment process.

1) Parking process: after the user pushes the non-motor vehicle to the designated site, the system will identify whether the user is a resident of the building, and then select the position. Due to the particularity of the parking device, the lower parking position, the less time it takes for to store and pick up the non-motor vehicle. When choosing the position for the first time, the bicycle will occupy the vacant position at the bottom on the basis of first come, first served.

2) Pick-up process: when picking up the bicycle, the system shall identify the identity again. After the identity of the householder is confirmed, retrieve the parking position of the non-motor vehicle stored inside. Then take out the non-motor vehicle according to the previous process, and record the time of picking up the bicycle and the householder's information.

3) Adjustment process: this system is scheduled to carry out an adjustment process at 2:00 am every day, to prevent the non-motor vehicles of some household owners from occupying the position near the bottom left for a long time, which leads to low efficiency of the whole system. First of all, the system will read the parking and pick-up records of all non-motor vehicles for calculation. The calculation rule is that the non-motor vehicles with parking and pick-up records within 24 hours have the highest priority, without changing the relationship between their position before and after, and the non-motor vehicles without parking records in 24 hours will be sorted according to the last recording time. After completing the calculation, regulate according to the sorting order intelligently. Finally, record the adjusted location information of all users' non-motor vehicles[8].

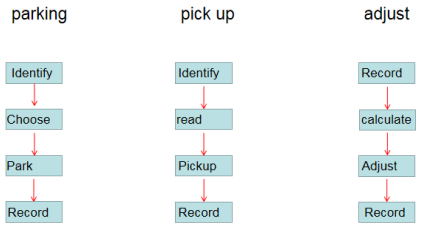

Fig.4 Flow chart of parking and pickup

IV. EXPERIMENTAL RESULTS

Fig.5 shows the picture of the product, which the part marked by a circle provides power mounted on the top of the building. Fig.6 shows the details of the finished product, which displays left and right power, and operation mode of the horizontal transportation platform. Fig.7 shows the running process diagram, which exhibits the intermediate state of the transport bicycle.

Fig.5 Picture of physical product

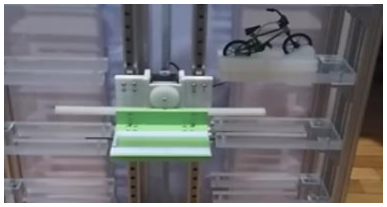

Fig.6 Details of finished product

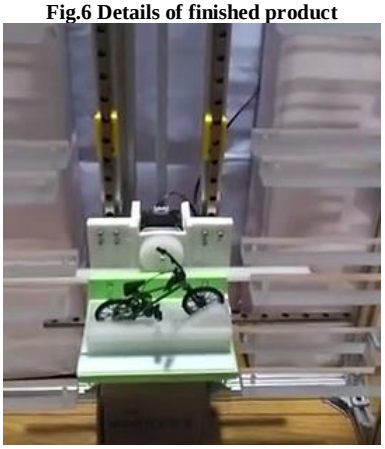

Fig.7 Running process diagram

The test verifies that this scheme can meet requirements of parking and pick-up ideally in many aspects. It can be seen from the model that the floor area and structure are under the scope of reality and feasibility. The smooth running of the model also proves that the logic and control algorithm are valid and efficient. However, considering the limitations of the model, the scheme needs further optimization in the aspects of stress, construction difficulty and economic benefits.

V. CONCLUSION

Nowadays, it is the time to advocate green travel, and it is an urgent matter to solve the worries about green travel. Compared with prior art, this garage has the following advantages:

The garage frame itself is set with the periphery wall of the tall building as the attachment. Using the space of the side wall and multi-layer structures for non-motor vehicles, it can save the ground area of compact community, and leave space for the underground garage relieving the pressure of car parking. The structure of the garage is reliable and the maintenance frequency is low. The non-motor vehicles can be fixed by rings and slings hanging on tripod, which improves the bearing and the reliability of vehicle parking. Intelligent controller and units can realize high degree of automation for parking non-motor vehicle, and have broad application and market prospect for the public.

In the more developed era of Internet of things in the future, the garage will achieve higer intelligent development in terms of promotion and applicability introducing facial recognition system.

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REFERENCE

[1] FangFei Zhong, Liang Zhu, XianJun Huang, Bin Zhou, BoHong Zhang, Shuang Yu, XuDuo Zhao. "*Design of hydraulic system for self-garage with hydraulic elevator[J]".* Gansu Science and Technology, 2016, 32(01):10-12

[2] Wei Li. "*Current situation and development strategy of three-dimensional garage in China [J]".* Equipment Management and Maintenance, 2019(09):12-13

[3] Qin Wang, LiangFa Yang, Zhen Zhang, MiaoMiao Zhang. "*Current situation and development trend of development and application of bicycle parking device[J]".* Modern Machinery, 2009(05):82-84+95.

[4] Rui Wang, Wang Yao, ChangGui Liu, Fan Cao, OuYa Xing. "*Innovative design of non-motor vehicle parking facilities in old communities[J]".* Industrial Design, 2017(04):81+83

[5] ZhengJiang Wang, Lu Jing, Bin Zhu, ShenShang Cai. Journal of liaoning University of Engineering and Technology(Natural Science Edition), 202, 39(01):82-85.

[6] Jun Liu, Lan Yang, YanQin Chen. Journal of Shanghai Institute of Electrical Engineering, 2011, 14(01):21-25.

[7] QingLiang Yang, JianJun Zhao. "*Design of automatic locating stereo garage system based on single chip[J]".* Mechanical Engineering and Automation, 2008(01):161-163.

[8] Chen Liu. "*Design of lifting and translation stereo garage control system[J]".* Science and Technology Wind, 2019(04):5.