Peak-time and Energy-saving Garage based on Space Resource

Xu Yuming[#1], Zhang Chunyan[*2], Qu Guanxue[#3], Shen Lingyun[#4]

[#]*Shanghai University of Engineering Science*
333 Long Teng Road,Shanghai 201620,China

Abstract *— Aiming at the current situation of parking difficulties in old neighbourhoods, Peak-time and Energy-saving Garage based on Space Resource is researched and designed based on the space resources and the peak-time effect of parking. Use 3D modelling software to design the structure, and use the circuit module to realize the parking of the vehicle. Using the "Internet Plus" system, the garage is connected to the mobile phone APP via Bluetooth, making parking more convenient and intelligent.*

Keywords *— space resources, peak-time, garages, energy-saving*

I. INTRODUCTION

With the rapid development of today's society and the increasing disposable income of Chinese residents[1], 'buying a car' has become one of the key word in measuring the living standard of a family. Taking Shanghai as an example, at the end of 2016, the number of registered motor vehicles in Shanghai was about 3.6 million, and the vehicle ownership rate per unit area was about 580 vehicles / km2, having an increase of 8% over 2015. As shown in Figure 1 , the problem of 'difficult parking' in old neighbourhoods what is caused by insufficient 'garage design capacity and life conflicts caused by random parking intersections are also common.

There are different solutions to this 'difficult parking' problem[2], but the root of the analysis is not more than two solutions: the implementation of a stereo garage and the improvement of parking space. The stereo garage can effectively improve this dilemma. It uses space resources, but a complex stereo garage also requires empty space and a lot of labor to build, which is time-consuming and labor-intensive. In addition, in order to increase parking spaces and hinder normal commuting or reduce greenbelt, but this will obviously affect the quality of life of the residents; the 'night parking' in Shanghai and the 'enclosed parking' in Zhuhai can only reduce part of the time difficulties but still have a few limitations.

How to make up for the weaknesses on the basis of the existing technology and explore new ideas is the basic direction for our team to solve the problem [3]in accordance with the current situation of this society.

Fig 1. Parking situation

II. IDEAS PROPOSED

At present, the existing basic parking spaces in old neighbourhoods quarters in the country are all one car on the ground. Using the vertical space, the original park is transformed into a new parking lot. 'One parking for two cars.' In addition, during the interview, we found that the commuter roads in the community were mostly surrounded by greenbelt of low bush. Developing the upper space resources, and created parking spaces from the original places without parking spaces. Greatly alleviate the problem of parking difficulty, and put forward the innovative concept of 'parking in the air'. Compared with the centralized large-scale stereo garage, it greatly reduces the trouble of land planning, long construction time, and the high expense.

With the prevalence of the sharing economy in recent years, the booming of shared bicycles has brought convenience to people, and it also causes a bad habit of parking disorderly, resulting in congestion on commuting roads and hidden safety hazards. Can we solve the parking problem of motor vehicles while solving the parking problem of non-motor vehicles at the same time, and alleviate the two major parking problems?

III. DEVICE DESIGN

A. Overview

Peak-time and Energy-saving Garage based on Space Resource as shown in Fig 2, includes two major parts: the main mechanical frame[4] and the electromechanical power control system. The main frame consists of solar panel, support arm (straight arm), vehicle board, auxiliary vehicle board and support arm (folded rod), the electromechanical power control system includes a turbine worm[5] Fig

3, a reduction gear set, a stepper motor, and a transmission shaft, gears, etc.

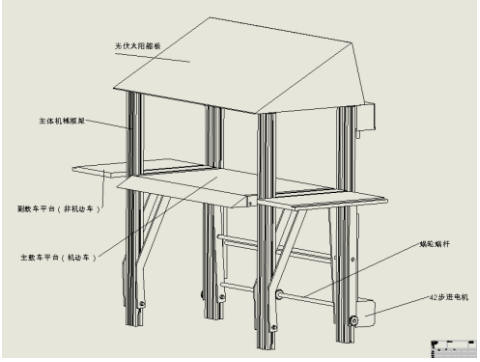

Fig 2. Device diagram

Fig 3.Parking situation of worm and gear

B. Brief Introduction of Mechanical Design

As shown in Fig 4, the main body is a stereo garage mounted on the ground. The bottom of the stereo frame is equipped with two sets of brackets. The other ends of the group of brackets are hinged on the back of the car board. The output shaft is connected with the worm and the turbine worm transmission mechanism of the reduction mechanism.

In the vehicle ascending operation, the straight arm as the active part is driven by the forward rotation of the stepper motor to realize the parallel ascension of the parallel four-sided form of the host vehicle board. The other set of supporting arms is hinged on the parking plate of the non-motor vehicle. Because the non-motor vehicle and the actual weight are relatively small, only the single side supporting arm can bear the corresponding load weight. The stepper motor[6] is also used to control the two side plates. Movement complete the ascent operation.

The main frame is also installed when the lower computer starts to determine the current motor position after receiving the Bluetooth data. If the main and auxiliary car boards are at the ground position, and the motor rotates forward. After the above functions are achieved, the car board is raised to the upper position. Then stop and complete the parking operation. If the main and auxiliary car boards are in the upper position, the motor reverses to lower the vehicle. After reaching the ground position, the car picking operation is completed.

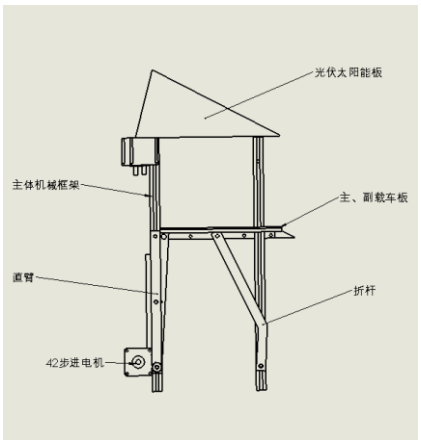

Fig 4. Lateral view of our device

C. Brief Introduction of Electromechanical Control and Power System

The electromechanical power control system uses a '42 stepper motor' with 0.28 N●m and a 4.0A driver hybrid linkage. The power supply

Fig 5.Arduino

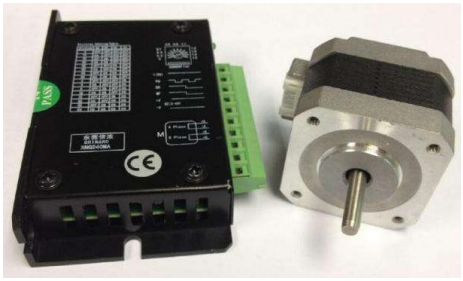

Fig 6.Stepper motor and drive

system uses photovoltaic solar panels, and the backup power source is the grid in the residential area. The two interact with each other to achieve a dynamic energy balance. The CNC system[7] is a Bluetooth module based on an Arduino chip[8].

D. Program Source Code Summary

a) Selection Parameters of Electromechanical Control System and Power Supply System

1 The power part of the electromechanical power control system uses the 42-stepper-motor (2BYGH34) and the 4.0A driver (TB6600).

2 The power supply device adopts a monocrystalline silicon photovoltaic solar panel of 100 watts. And the backup power source is four lithium iron phosphate batteries.

3 Chip adopts main control board UNO(R3) and Bluetooth module(HC05).

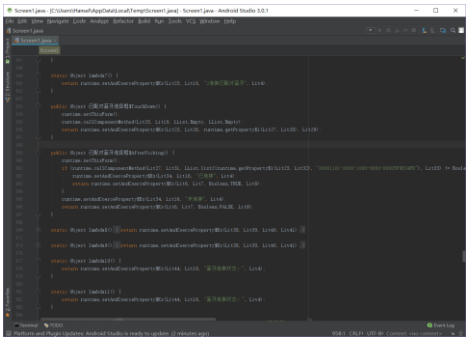

Fig 7. Procedure code

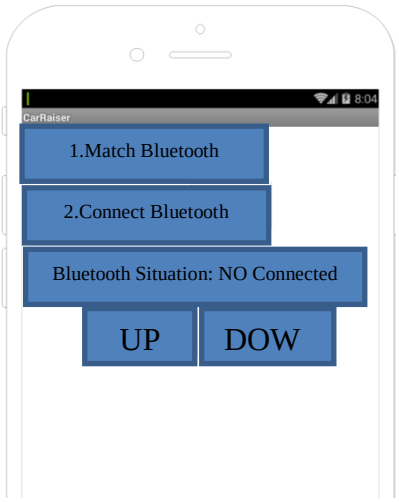

Fig 8. APP shows

b) Sensor Control Circuit

Because the I / O ports of the 51 single-chip microcomputers are all high-level by default, in the circuit design, using transistors, comparators and other components, the sensor signal is converted to low-level and passed to the single-chip microcomputer, so that the single-chip microcomputer can accurately sense the signal. Preventing the occurrence of the error of unknown cause, the sensor control circuit is shown fig 9.

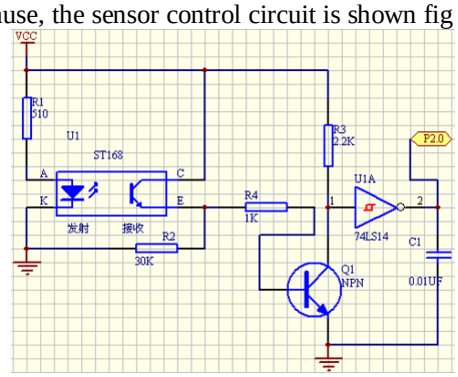

Fig 9. Circuit diagram

IV. DESIGN CALCULATIONS

A. *Overall Design Conception and Scene Simulation*

Figure 9 shows two applicable environments of the peak-time and energy-saving garage based on space resource development:

①It can be placed in the side parking space on the side of the road, increasing the number of effective parking spaces and effective parking area. And during off-peak hours, the devices are connected to each other and an 'air corridor' is set up to avoid the parallel movement of people and vehicles, facilitate the elderly and children to commute, and realize the separation of people and vehicles.

②It can be placed on a relatively flat green belt, where a brand new 'air' parking space is added, which not only increases the number of effective parking spaces and effective parking area, but also does not affect the overall landscape and green growth of the community.

B. *Determination and Calculation of Basic Parameters*

According to market research and analysis, the statistical data table of the best-selling cars is shown in Table 1 :

TABLE Ⅰ: THE PARAMETER VALUE OF AUTOMOBILE

Model parameters	POLO	Ford F150	Changan YueXiang	Hummer H3
Length (mm)	3970	4765	4900	4742
Width (mm)	1682	1750	1860	1897
Height (mm)	1462	1860	1500	1892
Weight (Kg)	1120	1690	1595	2132

The geometric parameters [9]of the car are set as follows: the body length is about 4m, the body width is about 1.7m, the body height is about 1.6m and the total weight is about 3000 Kg. The size of the car board should be larger than the size of the car. Thus, the car board's length is 5m and width is 2m. In order to ensure the free movement of the car board, the distance between the left and right pillars should be wider than the width of the car board. It is so that this is not only conducive to the access of the car, but also to the placement of the car board. The distance between front and rear pillars is set to 2m and the distance between the left and right uprights is set to 6m.

C. *Car Board Stiffness and Strength Issues*

Car board (including motor vehicle) is selected as the research object, which is analyzed by its load-

carrying board, maintaining at a level during the movement. The material is made of patterned steel plate welding and bending. The welding seam is manual arc welding. After welding, it is annealed.

Car plate weight = 630kg = 6300 N. Car plate rated load = 3000 kg= 30000N

Since the four supporting arms are simultaneously loaded, the normal stress on each member is:

$$F_1\cos 30° + F_2\cos 60° = \frac{W_1 + W_2}{2}$$

$$F_3\cos 30° = F_1\sin 30° + F_2\sin 60°$$

The analysis[10] assumes that the carrying capacity of the straight arm and the folding rod in the supporting arm is the same. Calculated from

$$F_1 = 13286N$$

$$F_2 = 13286N$$

$$F_3 = 20957N$$

D. Load Calibration and Material Selection

①Since the pulley is fixed at the top of the pillar, the pillar can be simplified approximately as a cantilever beam. The maximum stress on the pillar is:

Where - maximum bending moment of the beam;

Where - section modulus;

②The bending section coefficient is related to the material of the pillar. ‘Consult the Mechanical Design Manual’ to know that the bending section coefficient of the selected steel bending is:

$$M_{\max} = F_1 * \frac{\sqrt{3}}{2} + F_2 * 1 = 24792N \bullet m$$

$$\sigma_{\max} = \frac{M_{\max}}{W} = \frac{24792}{\frac{4.09 * 10^{-5}}{2}} = 303.08MPa$$

E. Motor Speed and Number of Rotations

The stepper motor is used to precisely control the speed and the number of forward and reverse rotations which is in order to achieve a smooth rise of the car board to the specified position. After receiving the Bluetooth data, the lower computer Arduino starts to judge the current motor position and realizes one-button control.

V. CONCLUSION

Main Innovations

①The main mechanical frame can be placed on the original parking space or the flat green belt area, with a small amount of work and a wide range of applications.

②Take the “peak” as the starting point to achieve different utilization in different periods and break the existing single restriction of “only adding parking spaces”.

③This device can alleviate the two problems of difficult “parking of motor vehicles” and “random parking of non-motor vehicles”.

④ Use photovoltaic solar panels as the device power system and connect to the residential grid to achieve dynamic energy balance while avoiding waste of resources and power shortages.

⑤Incorporate the innovative model of “Pedestrian Overpass”. During off-peak hours, this device can be connected to each other to form an “air corridor”, eventually forming a “overpass system” in the residential area, avoiding the parallel use of people and vehicles and facilitating the passage of residents.

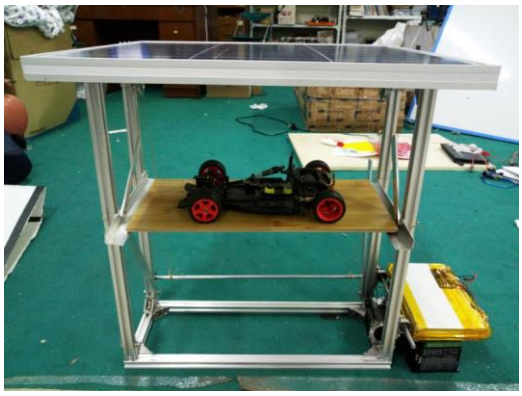

Fig 10. Picture One

ACKNOWLEDGMENT

This research was supported by National Training Programs of Innovation and Entrepreneurship for Undergraduates (Grant No.201910856001)

REFERENCES

[1] Park So Hyun,Bae Mi Ae,Han So Hee, Cheng Si Yao,Kim Sung Hoon,Chang Kyung Ja. Consumption Patterns and Importance-Performance Analysis of Home Meal Replacements by Level of Taurine-Related Nutritional Knowledge in Korean Adults.[J]. Advances in experimental medicine and biology,2019,1155.

[2] Evgueni Douissembekov,Catherine Gabaude,Joceline Rogé,Jordan Navarro,George A. Michael. Parking and manoeuvring among older drivers: A survey investigating special needs and difficulties[J]. Transportation Research Part F: Psychology and Behaviour,2014,26.

[3] Kolev Ognyan I. Self-Motion Versus Environmental-Motion Perception Following Rotational Vestibular Stimulation and Factors Modifying Them.[J]. Frontiers in neurology,2019,10.

[4] Teresa Radziejewska, Piotr Gruszka, Joanna Rokicka-Praxmajer. A home away from home: a meiobenthic assemblage in a ship's ballast water tank sediment[J]. Oceanologia, 2006, 48(S).

[5] Luo Wenjun,Chen Yonghong,Chen Yan,Zhang Guanghui. Computerized simulation of tooth contact for planar internal gear enveloping crown worm drive with errors[J]. Proceedings of the Institution of Mechanical Engineers,2018,232(9).

[6] Huang Gang,Li Zhengtan,Fukushima Edwardo F,Zhang Changfan,He Jing. An equivalent-input-disturbance approach for current sensor faults estimation and rejection

in permanent magnet synchronous motor drives[J]. Transactions of the Institute of Measurement and Control,2020,42(3).

[7] Georgi M. Martinov, Aleksandr B. Ljubimov,Lilija I. Martinova. From classic CNC systems to cloud-based technology and back[J]. Robotics and Computer-Integrated Manufacturing,2020,63.

[8] Anel Beganović,Thomas Nuener, Florian Meischl, Stefan E. Stuppner, Matthias Rainer, Günther K. Bonn,Christian W. Huck. Quantification of melamine in infant formula using a handheld Raman spectrometer – Performance boost with customized Arduino-controlled rotation setup[J]. Talanta,2020,209.

[9] Gao Xiang,Niu Junchuan,Jia Ruihao,Liu Zhihui. Influential characteristics of electromagnetic parameters on self-powered MR damper and its application in vehicle suspension system[J]. Proceedings of the Institution of Mechanical Engineers,2020,234(1).

[10] Jan Kraft, Carl Fällgren, Michael Vormwald. Calculation of Stress Intensity Factors from Shell Elements under Mixed Mode Loading[J]. International Journal of Fatigue,2019.