Mechanical smart cleaning table

Jinhong Duan¹, He Gan², Quanzhang Yu³ and Yun Chen*¹

¹ Department of Logistics Management and Engineering, Wuhan University of Technology, Wuhan, Hubei, 430070, China
² Department of Mechanical Engineering and Automation, Wuhan University of Technology, Wuhan, Hubei, 430070, China
³ Department of Mechanical Engineering and Automation, Wuhan University of Technology, Wuhan, Hubei, 430070, China
* Corresponding author’s e-mail: 287836@whut.edu.cn

Abstract. Smart home is the inevitable development trend of future home furnishings. As an integral part of the home system, the dining table is bound to face a qualitative leap. As people yearn for a better, more comfortable and convenient life, the development of the dining table will become more intelligent and humanized. At present, people have a great demand for a variable dining area, and hope to avoid the tedious cleaning of the table after eating, and desire to be free from housework. Based on the above background, the team members designed a new type of self-cleaning dining table-mechanical intelligent cleaning dining table. The dining table has the characteristics of ingenious structure, diverse functions and stable performance, including three functional modules: folding and extending, table cleaning, and garbage collection. The ingenious cooperation between the various institutions can realize the folding and extension of the dining table, table cleaning and garbage collection functions. The mechanical intelligent cleaning table saves people's time, facilitates people's lives, and has high practical value and promotion value.

1. Research background and significance

1.1. Research background

The smart home market has entered an era of rapid development. Products such as smart door locks, smart air conditioners, and smart refrigerators have been widely loved by people. Therefore, people seek more opportunities to build more smart home products to improve people's quality of life. The dining table is an important part of the home, and people are eager to innovate on it to facilitate people's lives.

However, the current innovations in the dining table cannot meet people's needs well. The limited living space makes it difficult for people to choose the size of the dining table. There is nowhere to place the larger dining table, and the smaller dining table cannot meet people’s dining needs when guests come to their homes. The cleaning of stains on the dining table after dinner is even more difficult. As we all know, the cleaning of oil stains requires not only the use of detergents, but also the cleaning of multiple processes. If it is not cleaned, it will require more vigorous cleaning or even impossible to clean over a long period of time.

Based on the above background, a dining table with both folding, extension and cleaning functions was designed.
1.2. Research significance
(1) According to the needs of users, the dining table can be folded, extended and self-cleaned, which is convenient for people's lives and helps people to free themselves from housework.

(2) The design goal of the dining table is to integrate into the smart home system and contribute to the overall improvement of people's quality of life.

(3) At present, there are fewer dining tables with cleaning functions on the market, and the design is more innovative and practical.

2. Overall design

2.1. Mechanical structure design
The mechanical structure design is the core of the research on the smart dining table, and the research on the mechanical structure that satisfies good stability, less space, small weight, and complete functions is the focus of research. The mechanical structure of the system mainly includes: folding and extending device, desktop cleaning device, garbage collection device. The base of the smart dining table constitutes the basic frame of the system, which supports the entire dining table. The cam-link combination mechanism completes the folding and extension of the desktop. The motion of the friction wheel trolley and the parallel four bars completes the horizontal and vertical motion of the cleaning scraper, which scrapes the garbage on the table to the designated side of the table. The space linkage mechanism prevents the desktop garbage from leaking from the side of the desktop. The hinged four-bar mechanism makes the trash can move from the bottom of the desktop to the outside of the table to collect the garbage on the desktop.

2.2. Control system design
The control system is an important content of the research on the smart dining table, and the Internet of Things and electromechanical control are the focus of this part of the research. This system adopts the concept of modular design combined with main control and auxiliary control. The main control part adopts the cost-effective open source single-chip Arduino mega2560, which is responsible for controlling the forward and reverse rotation of the motor and receiving signals transmitted by the auxiliary control. The auxiliary control part adopts Arduino uno. It is mainly responsible for receiving the instructions transmitted by the mobile phone APP, detecting the current on each motor and indirectly detecting whether the motor is blocked, so as to avoid the organization from accidentally injuring the user.

3. Module design

3.1. Folding extension module

Figure 1. Structure of folding extension module
The folding extension module is composed of a cam-link combination mechanism and table tops. Figure 1 is a three-dimensional view of the folded and extended module. The connection method is:
the cam is fixed on the middle tabletop, the three connecting rods are bound to each other by thimble, and the connecting rods on both sides are fixed on the two tabletops through shafts. The middle connecting rod is equipped with a motor at the center, and the motor drives the connecting rod to move, which can drive the movement of the connecting rods on both sides and the movement of the thimble on the spatial cam. The connecting rods on both sides drive the fixed tabletops to move to both sides. The movement of the thimble on the space cam makes the middle tabletop rise to form a complete large tabletop. The folding process is the reverse movement of the extension process.

3.2. Desktop cleaning module

![Figure 2. The condition of the table when it is not working](image)

The desktop cleaning module is composed of a friction wheel trolley, a parallel four-bar, a scraper and a space linkage mechanism. When not in use, the scraper is hidden under the desktop. When in use, the friction wheel trolley and the parallel four rods drive the scraper to the top of the desktop and continue to move in the horizontal direction to scrape the garbage to the designated side of the desktop. The space linkage mechanism is used to gather the stains in the middle to prevent the stains from leaking from the side of the desktop. Figure 2 is a three-dimensional view of the dining table when it is not working.

3.3. Garbage collection module

![Figure 3. The state of the table at work](image)

The garbage collection module is composed of a hinged four-bar mechanism, a garbage can and an ultrasonic cleaning tank. The hinged four-bar mechanism is fixed under the two desktops, so that the entire module can move with the movement of the two desktops. When working, after the desktop cleaning module scrapes the garbage to the side of the desktop, the hinged four-bar moves the trash can from below the desktop to the outside of the table. During the whole process, the trash can is translated and rotated 90 degrees. The ultrasonic cleaning tank is installed above the trash can. The
scraper can enter the ultrasonic cleaning tank for self-cleaning. After cleaning, the water in the ultrasonic cleaning tank will also be poured into the garbage. In this process, the relatively large trash can completes translation and rotation without colliding with the table, with smooth movements and strong stability. Figure 3 is a three-dimensional view of the dining table at work.

4. Feasibility analysis

4.1. Folding and stretching
We use matlab software to analyze the trajectory of the thimble and the desktop, which can meet the middle desktop to rise to the extreme position, the two sides of the desktop spread out, three desktops just to form a full large desktop requirements.

4.2. Desktop cleaning
During the cleaning process, the Adams software was used to analyze the trash can trajectory, and it was found that the trash can can move to the outside of the table without touching the table.

4.3. Garbage collection
Through the static analysis of the connecting rod by using Ansys software, it is concluded that the scraper can scrape the desktop garbage to the designated side of the desktop through friction within the range of the connecting rod bearing desktop pressure.

5. Innovation point
(1) Innovative design of the cam-link combination mechanism. Using an original moving part to realize the opening and closing of the two desktops and the lifting of the middle desktop, greatly improving the work efficiency.

(2) Innovative application of the hinged four-bar mechanism. By determining the length of each link, a hinged four-bar mechanism was designed to subtly drive the larger bin along the track from the bottom to the outside of the counter.

(3) Combining folding and extending, desktop cleaning and garbage collection. It can solve a series of problems faced by dining, and it is a multifunctional electromechanical device.

6. Conclusion
By analyzing the problems of existing dining tables and combining with the future development prospects of smart homes, we have designed a dining table that can be folded, extended and cleaned to improve people's quality of life and make people's family life more comfortable and convenient. Compared with the existing market, this dining table has a great market prospect and hopes to bring more people a high-quality experience.

Acknowledgments
I would like to thank my teachers for their careful guidance in the research process, my teammates for their trust and support, and my parents for their continuous encouragement in the research process. In the days to come, I will study harder and exert myself value!

References
[1] Chen, X.C., Yang, G., Zhou, J. (2014) Mechanical Principle and Mechanical Design. Higher Education Press, Beijing.
[2] Sun, J.M. (2003) Mechanical Optimization Design. China Machine Press, Beijing.
[3] Zheng, X.B. (2011) Technology of Mechanical Manufacture. China Machine Press, Beijing.
[4] Tong, B.S., Wu, Z.J., Li, X.Z., Feng, J. (2008) Fundamentals of Mechanical CAD Technology. Tsinghua University Press, Beijing.
[5] Liu, H.W. (2017) Mechanics of Materials. Higher Education Press, Beijing.