Future Ceiling Design Based on Fischer

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Abstract. This design cleverly integrates modern machinery and control technology into the home system, and cleverly combines intelligent machinery and intelligent life, making family life more intelligent, comfortable and convenient. Use the ceiling as the carrier to realize the three-dimensional home design, make full use of the indoor top space, and solve the problems of small residential space and difficult storage. The main functions contained in this device are stored indoors. The introduction of this design conforms to the trend of intelligent family life and greatly facilitates people's daily life.

1. Design ideas
With the continuous advancement of urban modernization, my country's real estate prices continue to rise, while my country's per capita living area continues to decline. In order to meet the needs of modern people for comfortable and livable housing, how to make full use of indoor space is an important content of house decoration design.

Through the research of multiple residential units, we found that in recent years, the housing units have shown a new trend—relatively smaller living area and higher indoor floor height, which makes it possible to use the space above the ceiling. However, the current utilization of the space above the ceiling is almost zero. This design is based on the advantages and disadvantages of wall lockers, makes full use of the space above the ceiling, based on modern intelligent technology (intelligent control, remote control technology, infrared sensor positioning technology, etc.) and mechanical structure innovation, designed a set of embedded ceiling upper floors. The complete smart home system of the space, including smart storage and automatic storage of furniture (such as bookcases, desks) and other functions, greatly freeing up the indoor space, enabling small-sized families to have a "multi-functional, large-space" comfortable living environment.

Figure 1. New urban housing pattern—relatively smaller living area and higher indoor floor height.
2. Overall scheme design
The smart ceiling home system is mainly composed of smart storage modules, bookcase lifting modules and desk lifting modules. Among them, the smart storage module can classify and store different types of items in the ceiling, and the bookcase lifting module and the desk lifting module can respectively store the bookcase and desk in the ceiling. The overall physical map is as follows:

![Overall physical picture of the device.](image1)

**Figure 2.** Overall physical picture of the device.

2.1. Smart storage module
The intelligent storage module is mainly composed of a lifting platform, a storage platform and a handling device. The items are lifted to the ceiling through the lifting platform, and the handling device can switch the items between the lifting platform and the storage platform to complete the access to different types of items.

![Physical model of smart storage module.](image2)

**Figure 3.** Physical model of smart storage module.

2.1.1. Analysis and verification. According to the graphic method, under the action of the slider with rod, the storage box moves horizontally, and the distance between the axis distance $d_1d_2$ decreases. From the Pythagorean theorem, the distance from the tangent point to the center of the driven wheel decreases, so when the tangent $X$ is the length of the rod greater than the distance $X$ from the tangent point to the center of the circle, it can be ensured that the mechanism can pull it onto the conveyor belt. The size of the home design can be obtained, the length $L_1$ of the rod with the rod slider is 16mm, when the position shown in Figure, the rod with the rod slider is tangent to the rod of the locker, and the locker 3 the diameter $D_1$ of the rod is 10mm. According to the measurement, the axis distance $d_1d_2$ between the driven gear and the slider with rod is 24mm, and the diameter of the driven wheel $D_2=33$mm. The distance from the tangent point to the center of the gear is $Y$.

The distance from the tangent point to the center of the gear is:

$$X = \sqrt{d_1d_2^2 - (\frac{D_1}{2})^2}$$  

(1)
According to calculation $X=23\text{mm}$

Conditions that need to be met when the slider bar can pull up the locker:

$$X - \frac{D^2}{2} \leq L$$

(2)

According to calculations, this condition can be met.

2.2. **Smart storage module**

The bookcase lifting module is mainly composed of a screw-scissor mechanism, and the eccentric scissors mechanism is driven by the screw to realize the flip of the bookcase, so as to achieve the purpose of lifting the bookcase.

![Figure 4. Picture of bookcase lifting module.](image)

2.2.1. **Design and Motion Analysis of Lifting Mechanism of Bookcase.** This part realizes the lifting of the bookcase. When the bookcase is not in use, it is stored in the upper space of the ceiling. While meeting the user's demand for reading books, the upper space of the ceiling is fully utilized and the indoor space is finally fully utilized.

![Figure 5. Picture of bookcase lifting module.](image)

1. Motor 2. Slider 3. Screw 4. Connecting rod 5. Connecting rod 6. Long connecting rod 7. Short connecting rod.

The linear motor 1 drives the screw rod 3 to rotate, and drives the slider 2 on the screw rod 3 to make a horizontal linear motion. Through the angle change between the scissors mechanism composed of the connecting rods 4, 5, 6, and 7, it drives to be fixed on the connecting rod. This can realize the lifting of the bookcase.
2.2.2. Analysis and verification. Available from ergonomics and common household sizes, the best height for picking and placing items when standing is between 95-150 cm. Assuming that the original length of the single rod is X, the scissor mechanism is Y level, the initial angle is α, and the rotation angle is β. Then the total original length of the scissor mechanism is:

\[ L = XY \sin \alpha \]  \hspace{1cm} (3)

The elongation of a single section of the scissor mechanism is:

\[ \Delta L = X (\sin (\alpha + \beta) - \sin \alpha) \]  \hspace{1cm} (4)

The total elongation of the scissor mechanism is:

\[ \Delta L_{\text{total}} = XY (\sin (\alpha + \beta) - \sin \alpha) \]  \hspace{1cm} (5)

![Figure 6. Analysis diagram of angle change of scissor mechanism.](image)

In the eccentric scissor mechanism, assume that the short rod is X1, the short side of the long rod is X2, the long rod is X3, and the initial angle is α.

\[ L_{ac} = X \cos \alpha \]  \hspace{1cm} (6)

\[ \gamma = \arccos \left( \frac{(X \cos \alpha)^2 + X_2^2 - X_1^2}{2X \cos \alpha X_2} \right) \]  \hspace{1cm} (7)

The single-section height of the single-section eccentric scissor mechanism is:
\[ L_1 = X_3 \cdot siny \]  

The single-section elongation of the single-section eccentric scissor mechanism is:

The conditions that need to be met are:

1. Keep the height of the device within 85mm during the limit contraction, so that it can be completely hidden in the upper space of the ceiling;
2. When in the extreme retracted position, the bookcase is kept in a horizontal position. When in the extreme extended position, the bookcase is placed vertically for easy access to books. Make sure that the total elongation is 170-200mm;
3. The scale of the model and the space above the ceiling need to be considered.

\[ XYsin\alpha + X_3 \cdot siny \leq 85mm \]  

\[ 170mm \leq X_3 \cdot \sin\left(arccos\left(\frac{X_2^2-X_1^2}{2X_2\cos(\alpha+\beta)}\right)\right)+XY\sin(\alpha + \beta) \leq 200mm \]

Based on the selection and measurement of Fischer parts, the final size is \( X=98mm, Y=1, X_1=55mm, X_2=55mm, X_3=128mm \), the initial angle is 25°, and the rotation angle is 46°. It is composed of a first-level scissor mechanism and a first-level eccentric scissor mechanism.

2.2.3. Bookcase lifting module program design.

![Figure 8. Bookcase flip module program diagram.](image)
As shown in the figure, the limit of the screw drive is realized by the phototransistor, which can accurately limit the flip angle of the bookcase. Compared with the mechanical limit switch, it reduces the extra load of the motor and can adjust the limit position more flexibly.

2.3. Desk lift module

The desk lifting module is mainly composed of a motor reel mechanism, a safety mechanism and a synchronous opening and closing mechanism. The synchronous opening and closing mechanism can match the hanging rod with the desk slot, so that the desk can be raised and lowered by the wire wheel to drive the hanging rod and stored in the ceiling. The safety mechanism uses the crank slider mechanism to close and lock the ceiling to prevent accidental falling of the desk and improve the safety of desk storage.

Figure 9. Physical picture of desk lifting module.

This part is to realize the lifting of the desk. When the desk is not in use, it is stored in the upper space of the ceiling. At the same time, a safety device is designed on the ceiling to prevent the desk from falling due to power failure, so as to achieve the goal of making full use of the upper space of the ceiling.

In order to meet the separation of the desk and the long rod, we designed the mechanism as shown in Fig. 10.

Figure 10. Diagram of desk matching mechanism.

2.3.1. Analysis and verification. The size of the small desk is 1080 mm × 520 mm. In the design of the synchronous opening and closing mechanism, not only the scaling degree of the device, but also the storage space on the top of the ceiling and the adaptability of the device to different desks should be considered.

Figure 11. Calculation and analysis of desk matching mechanism.

Assume that the length of the middle shaft is x, the length of the connecting rod is y, and the initial angle is α.
\[ L_{ac} = \sqrt{Y^2 - \frac{X^2}{4}\sin^2\alpha + \frac{X}{2}\cos\alpha} \]  

(11)

\[ H = X\sin\alpha \]  

(12)

The following conditions should be met:

1. The maximum width is slightly longer than the desk length, while the minimum width is slightly smaller than the desk length. The desk length model is 108mm.
2. The installation needs to be hidden above the ceiling.

According to the calculation and the size of Huiyu parts, \( Y = 75\text{mm} \) \( X=33\text{mm} \) can be obtained.

In order to realize the safe storage of the desk on the ceiling, without the risk of falling, we designed the safety mechanism as shown in Figure 12.

The stepper motor 1 drives the short shaft 3 to move, drives the cam 2 on the short shaft 3 to rotate, drives the push rod 5 installed on the cam to rotate, and pushes the board installed between the short connecting rod 4 and 6 to move. Through the long connecting rod 7 and 8, the slider 9 and 11 connected by the connecting rod 10 move along the long axis 12 and 13 respectively, and the wood board installed on the long link moves to realize the desk lifting module Opening and closing of ceiling and self-locking.

3. Application prospect

The device realizes the expansion of family space and intelligent application of ceiling, greatly facilitates people's daily life at home, and releases the indoor lower space. We hope that this new product can enter people's daily life in the future.

3.1. Self-improvement and perfection of products

After the four modules of the device are put into use, they need to learn deeply through continuous interaction with users, so that users can get a more comfortable experience. The intelligent storage module can learn the user's classification storage habits, arrange the storage space in the ceiling orderly, respond to the user's command faster, and complete the identification and access of the storage cabinet more quickly. Intelligent storage can be flexibly installed according to the interior decoration layout to meet the different needs of users. Finally, the four modules will form an intelligent unified system on the ceiling, which makes the device has strong adaptability and versatility. When it is really applied to the home, all the modules can be set to voice control. Through intelligent voice interaction, the automatic switch and viewing angle adjustment of the video and audio system can be controlled. After the work is completed, it can be automatically stored into the ceiling to maximize the convenience of people's life.

3.2. Promotion value

The purpose of the device is to expand the indoor space, so that the combination of mechanical mechanism and intelligent technology can enter the family, effectively solve the current people's demand for intelligent life, and achieve the unity of functionality and aesthetics. The design of the device
is novel, trying to use the space of the ceiling, but there is no similar home device in China. The smart home device based on the ceiling can not only effectively save the space occupied by the lower floor, but also switch the different activity modes of the family, bringing the smart life into thousands of households.

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3.4. Comprehensive prospects

The idea of smart home system based on ceiling is rooted in the current situation of the majority of families, and is committed to using advanced technology to meet the demands of the public. It has a good promotion prospect in urban apartments, so it has a strong advantage in the future competition of intelligent furniture market.

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