International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 3 Issue 5 ǁ May. 2015 ǁ PP.57-61

An Automatic Folding System Based on the Research of Quilt Folding

LIN Nan[1], JIN Xiao-yi[2], ZHAO He-xiang[3], SUN Li-bin[3], CHEN Hua-qiu[3]

School of Mechanical Engineering, Shanghai University of Engineering Science, Shanghai

ABSTRACT: The folding system is designed on a movable platform which above the bed and the stepping motor on the platform drives the strings fixed on the quilt in order to realize the secondary fold of the quilt. Because of the quilt is a flexible body, a means called stepping fixed method is used to reduce the freedom of the quilt until the flexible body is under the controllable state and complete the secondary fold. At the same time, sleep comfort is ensured on account of the strings is non-contact to human body.

Keywords: automatic quilt folding, stepping fixed method, secondary folding

I. INTRODUCTION

Folding the quilt automatically in a small place is an important research in smart home [1]. There are two ways of current schemes [2-3]: to use a pipeline or paving the quilt in a plane. The first method is applied in large-scale manufacturing and the second one can't realize the folding affect. So the following paper based on the research of the quilt folding in a small place and a platform with 4 stepping motors is designed to realize the quilt folding.

Because the folding system is for civil use, strings driven by the stepping motors is used to change the state of the target quilt. It can simplify the mechanical structure and ensure the sleep comfort. By means of the stepping fixed method which uses the strings driven by stepping motors to reduce the freedom of the quilt, the system should satisfy the following requirements [4]:

(1)Take up a small place and ensure the sleep comfort

(2)By means of the stepping fixed method to realize a secondary quilt folding

(3)Folding time is about 40s

II. Analysis of the Quilt

2.1 The connection of the quilt

Before the fold, the state of the flexible body [5-6] is random and uncontrolled. A quilt has two surfaces named as A and B, shown in Fig.1. A is defined as a non-contact body surface and B is defined as a contact body surface during the sleep. On the other sides of the strings are rolled on a reel which fixed on the stepping motors to coil the strings by driving the motors.

There is a comfortable and soft hasp [7] at the *o* point. Before to start the folding system, buckle the suspended strings C with the hasp. Due to the surface B is contact to human body, there is no strings or other hard stuffs to interfere with sleep. Meanwhile, string A and B are under a relaxed state in order to ensure the sleep comfort.

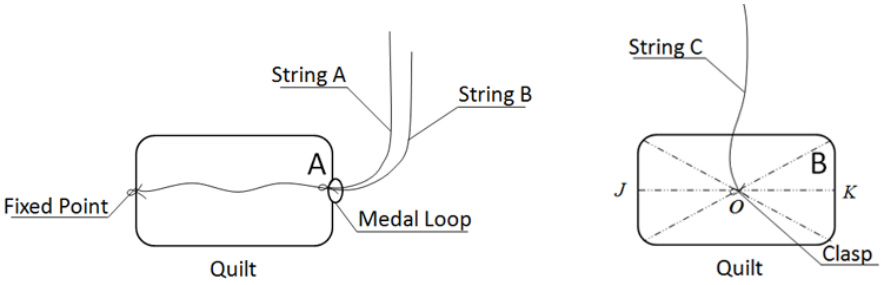

Fig.1 The connection of the quilt

2.2 The motion analysis of the quilt

Before folding, the quilt is a flexible body with a random state.According to the transport motion of the points A, B and C to the quilt to reduce the freedom of the quilt by stepping fixed method when the stepping motor drive the strings to expected sites until the quilt is under controlled state.

In order to analyze the movement of the flexible quilt. The quilt is regard as infinite layers [8], and the layer upon layer overlay the quilt to a complete entity. The layers are composed of numerous lines while the lines are composed of numerous points. During the folding, the *o* point is a fixed point, so the *o* point is the first point of the stepping fixed method. When the motor drive the string C to expected site, the point *o(0,0,0)* is be defined as coordinate origin, shown in Fig.2.The others points of the quilt is also random points besides the *o*.

The three points *J*, *O* and *K* are in the same line, shown in Fig.2. When the stepping motors drive the strings A and B, points *J*, *K* will coincide and be regarded as the second and third points of the stepping fixed method respectively.

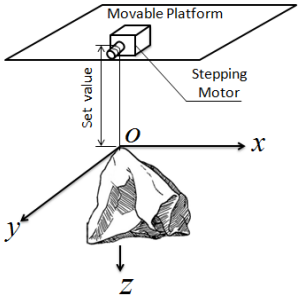

Fig.2 The coordinate origin

Because of the transport motion of the points are distributed on the segment $\overline{OJ}$ .The gravity on the remaining points make them link each other vertically. The quilt is composed of infinite layers, taking one layer as the research surface. In this case, the three-dimensional coordinate system is simplified as a two-dimensional coordinate system, shown in Fig.3.

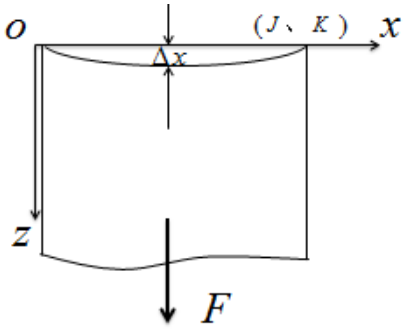

Fig.3 Layer of the quilt

The strings A and B are flexible body, because of the gravity on it, a displacement to *x* axis equals Δx . Δx << $\overline{OJ}$, so Δx is negligible. The points on the $\overline{OJ}$ line are distributed uniformly.

The quilt is now composed of infinite points in *xoz*. Take any point *p* on the *x* axis; there are infinite corresponding points q_i on the *z* axis. The points q_1~q_i link each other and array along the *z* axis vertically. So the points of the quilt shown in the matrix:

$$\begin{bmatrix} P_{00} & P_{10} & P_{20} & \cdot & \cdot & \cdot & P_{i0} \\ P_{01} & P_{11} & P_{21} & \cdot & \cdot & \cdot & P_{i1} \\ \cdot & \cdot & \cdot & \cdot & & & \cdot \\ \cdot & \cdot & \cdot & & \cdot & & \cdot \\ \cdot & \cdot & \cdot & & & \cdot & \cdot \\ P_{0j} & P_{1j} & P_{2j} & \cdot & \cdot & \cdot & P_{ij} \end{bmatrix}$$

The other points of each layer is similar, the matrix of these points is similar either. So each point on the flexible quilt can find the corresponding points in the matrix and they arranged in a certain distribution.

Because the quilt is flexible body, stepping fixed method is applied in the quilt folding to reduce the freedom of the quilt until the points of the quilt is arranged in a certain location. As the matrix, every points of the layer are arranged uniformly, so the whole quilt is under the controllable state.

III. Automatic Folding System

3.1 Movable platform

The folding system consists of four stepping motors, three of them drive the reels to coil the strings and the other one drive the lead screw [9]. Guide wheels are design to prevent, shown in Fig.4.

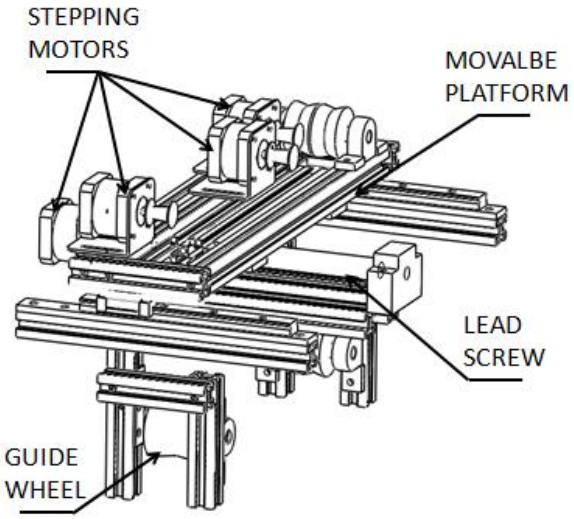

Fig.4 Movable platform

3.2 Mechanism motion

Three stepping motors drive the reel to lift the quilt and complete the secondary folding. The other stepping motor drives the platform [10] to put the quilt upon the bed after folding, shown in Fig.5.

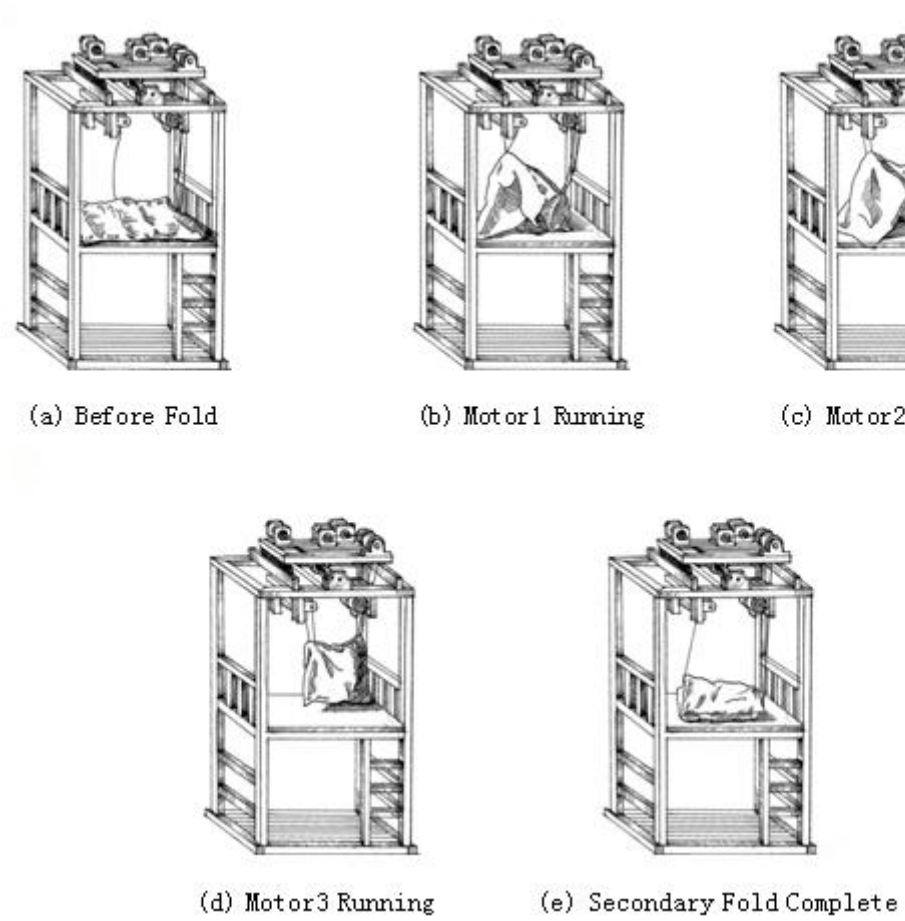

Fig.5 Mechanism Motion

IV. CONCLUSION

By establishing the three-dimensional coordinate system and find a fixed point on the quilt, the quilt is transfer into infinite points in the three-dimensional coordinate system. Because every point- layer of the quilt is similar, in order to simplify the research model of the quilt, one layer is picked up as a research layer. In this case, the three-dimensional coordinate system is simplified into a two-dimensional coordinate system. Based on the stepping fixed method, strings driven by the stepping motors are used to reduce the freedom of the quilt until the points of the quilt is under a controlled state.

(1).Establishing the stepping fixed method which can realize the flexible body folding in a small space and ensure the sleep comfort.

(2).Based on the coordinated control of four stepping motors and a movable platform which can realize the quilt folding for civil. The system is simple and makes the best use of space.

V. Acknowledgements

This work is supported by Shanghai University of Engineering Science High Level Project to Cultivate Special (Project No. cs1401003)

REFERENCES

[1] GAO Xiao-ping. State of the Arts and Developing Trend of Intelligent Residence in China[J]. Low Voltage Apparatus, 2005, (4): 19-20(in Chinese)

[2] SHUANG Qun, Wang Ming-xia. A New Type of Nonwoven Second Repeat Folding Machine[J]. Textile Machinery, 2014, (2): 33-34(in Chinese)

[3] LIU Tian-zhi, Zhang Xin-chang. High Speed Carton Automatic Folding M echanism and its Principle[J]. Packing Engineering, 2008, 29(2): 41-43(in Chinese)

[4] Paul Jackson. Folding Techniques for Designers: From Sheet to Form[M]. London: Laurence King Publishing, 2011. 189-194

[5] JIN Yu-zhen, LI Jun, ZHU, Lin-hang. Three-dimensional Numerical Simulation of the Movement of the Flexible Body under Different Constraints[J]. Journal of Thermal Science, 2014, (06): 593-599

[6] LIANG Li-fu. Quasi-variational principles of single flexible body dynamics and their applications[J]. Science in China(Series G:Physics,Mechanics & Astronomy), 2009, (05): 775-787

[7] Cornelius Lanczos, Physics. The Variational Principles of Mechanics[M]. America:Dover Publications, 1986. 78-90

[8] XU Xue-zheng. The Research and Design of Towel Folding Machine Control System[D]. JiLin:JiLin University, 2014. 13-14

[9] CHEN, Hua-hong. Triangular mesh simplification algorithm based on quadrilateral fold[J]. Acta Scientiarum Naturalium Universitatis Sunyatseni, 2008, (04): 22-27(in Chinese)

[10] SONG Guo-feng, Cheng Zhong-tao. Developing Status and Future Application of Motion Simulator and Its Motion System[J]. Machinery Design & Manufacture, 2008, (06): 231-234