Development of Inner Strings Haptic Interface SPIDAR-I

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ABSTRACT

This paper describes the design and implementation of an inner strings haptic device in 6-DOF, called SPIDAR-I. This device is developed to improve the calculational fidelity of position, orientation and force feedback for higher performance. Moreover, it promotes a new structure that strings and frame are inside the grip, so making it particularly compact in size for wider use.

KEYWORDS: SPIDAR, haptic device, user interface.

1 INTRODUCTION

As 3D virtual environment has been widely used, haptic interfaces are also drawing widespread attention. To all haptic devices, it is necessary to make further improvement on the calculational fidelity of position, orientation and force feedback for more real user experience.

This paper is based on SPIDAR[1], which is a wire-driven haptic device. Because its configuration of frame, grip and strings have a great effect on force display fidelity[2], we have discussed the optimization of the structure and developed the new SPIDAR-I with the optimal result, for a higher calculational fidelity of position, orientation and force feedback.

At the same time, the new type has been compacted into a smaller size and is expected for a wider application.

2 DESIGN AND IMPLEMENTATION OF SPIDAR-I

2.1 Derivation of SPIDAR-I

For the optimization of structure, we first modeled the SPIDAR into 3D space as shown in figure 1(A) and conducted the equations for position, orientation calculation and force feedback calculation. Because there is a relation between the two equations that when one` fidelity is improved, so is the other, we chose to discuss the former one. Then using Least Squares Method, it is simplified into (1).

$$M^T \Delta l = M^T M \Delta r \qquad (1)$$

Here if Δr decreases, the calculational fidelity will be improved. Therefore, we defined the evaluation function as (2) to increase the eigenvalues of the coefficient matrix $M^T M$ on average.

$$J = \left| M^T M \right| = \lambda_1 \lambda_2 \lambda_3 \lambda_4 \lambda_5 \lambda_6 \qquad (2)$$

After maximizing (2), we got the optimization result as follows.

$$D = \frac{1}{2} R,\ D_Z = \frac{\sqrt{2}}{2} R \qquad (3)$$

2.2 Design and implementation of SPIDAR-I

Depending on the optimal result of structure, we found it possible that strings and frame could be compacted inside the grip, so the overall size of the device has been much reduced. And the final design is shown in the figure 1(B).

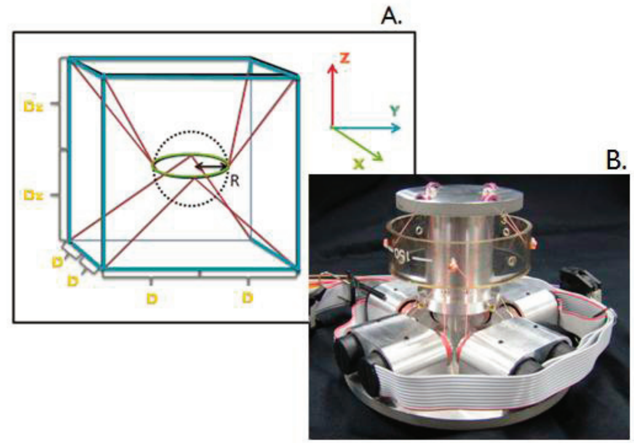

Figure 1. A is the model of SPIDAR and B is a picture of SPIDAR-I

3 EVALUATION EXPERIMENTS

The evaluation experiments have been executed as two parts, one is to measure the position and orientation by OPTOTRAK, the other is to measure the force feedback by load cell. And both of them compared SPIDAR-I to a classic type SPIDAR-G[3]. As a result, even the overall size is much reduced, SPIDAR-I still has a sufficient haptic perform in a high calculational fidelity.

4 CONCLUSION

A new type of haptic device called SPIDAR-I was proposed with a higher calculational fidelity of position, orientation and force feedback. At the same time, it has been designed as a particularly compact style in size, so making it possible for a wider use.

As the future work, the friction between strings and other components, which has a quite effect on force display, should be reduced. Moreover, in this paper, only home position of the grip was taken into account, it is necessary to consider the situations of other positions.

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