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Research on Virtual-real Biaxial Real-time Error Compensation Based on Fuzzy Control Theory

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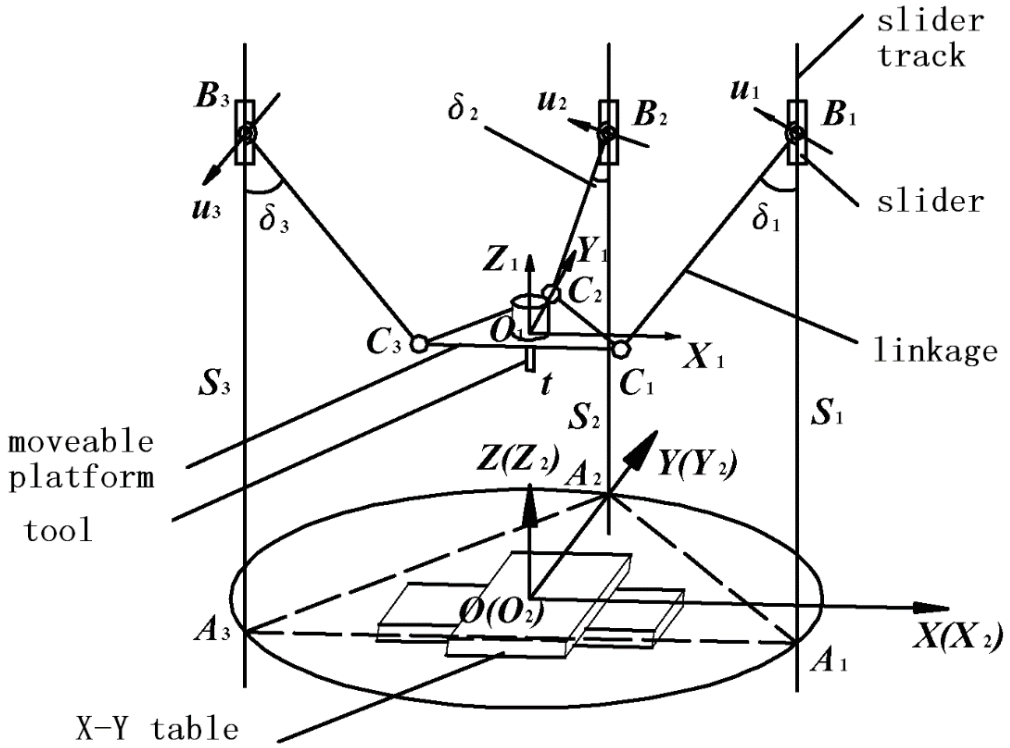
1. Introduction

- 1.Hybrid Machine Tool (Hybrid PMT), belongs to the concept of parallel machine tool category.
- 2.The hybrid machine tool mixes the parallel mechanism and the series mechanism, and combines the characteristics of the two.
- 4.To a large extent to solve the restrictions of limited machining region, so that the application of the parallel mechanism will be with more flexible and practical.

2. Virtual-real biaxial kinematics principle



(a) PRS-XY HMT（b）Coordinate frames

Fig. 1. PRS-XY HMT object and its Coordinate frames

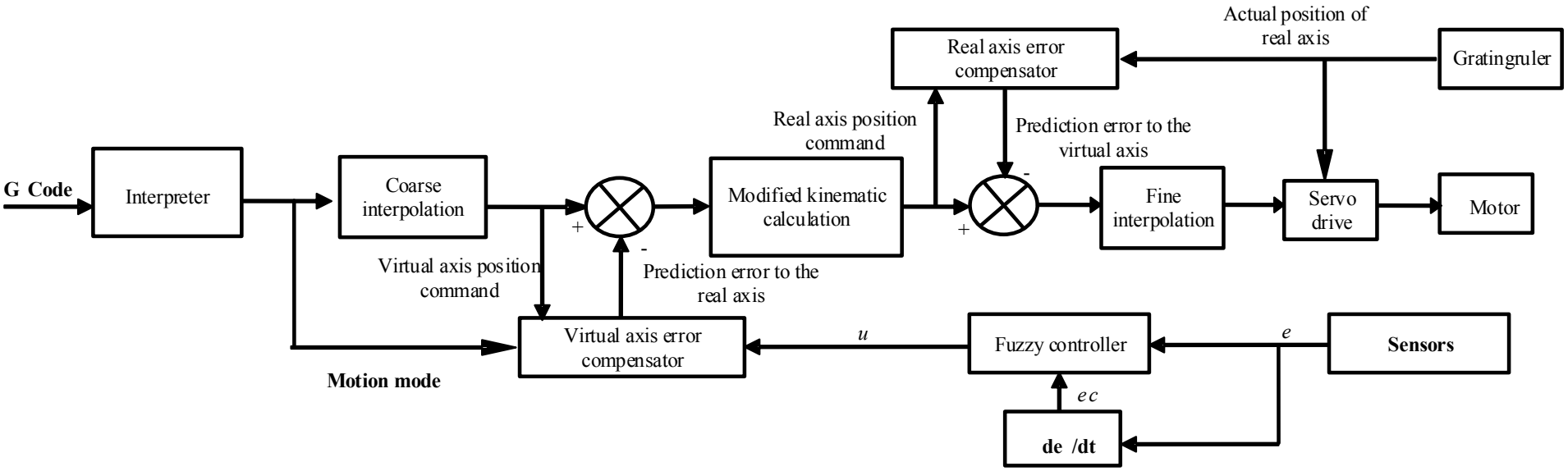
2. Virtual-real biaxial kinematics principle

- Virtual-real mapping relation of PRS-XY mechanism can be expressed as:

$$\begin{bmatrix} P_1 \\ P_2 \\ P_3 \\ P_5 \\ P_6 \end{bmatrix} = \begin{bmatrix} g_1(Q_1,Q_2,Q_7,Q_8,Q_9) \\ g_2(Q_1,Q_2,Q_7,Q_8,Q_9) \\ g_3(Q_1,Q_2,Q_7,Q_8,Q_9) \\ g_5(Q_1,Q_2,Q_7,Q_8,Q_9) \\ g_6(Q_1,Q_2,Q_7,Q_8,Q_9) \end{bmatrix}$$

1. Q1,Q2,Q7,Q8,Q9 are A, B, X, Y, Z virtual axis coordinates,
2. P1,P2,P3,P5,and P6 are rotary sub-joint B1 (linear motor drive 1), rotary sub-joint B2 (2 linear motor drive), B3 (3 linear motor drive), table X direction (X motor drive) and table Y direction (Y motor drive) joint coordinates, gi for the inverse function.

3.The hardware design of virtual-real biaxial real-time error compensation

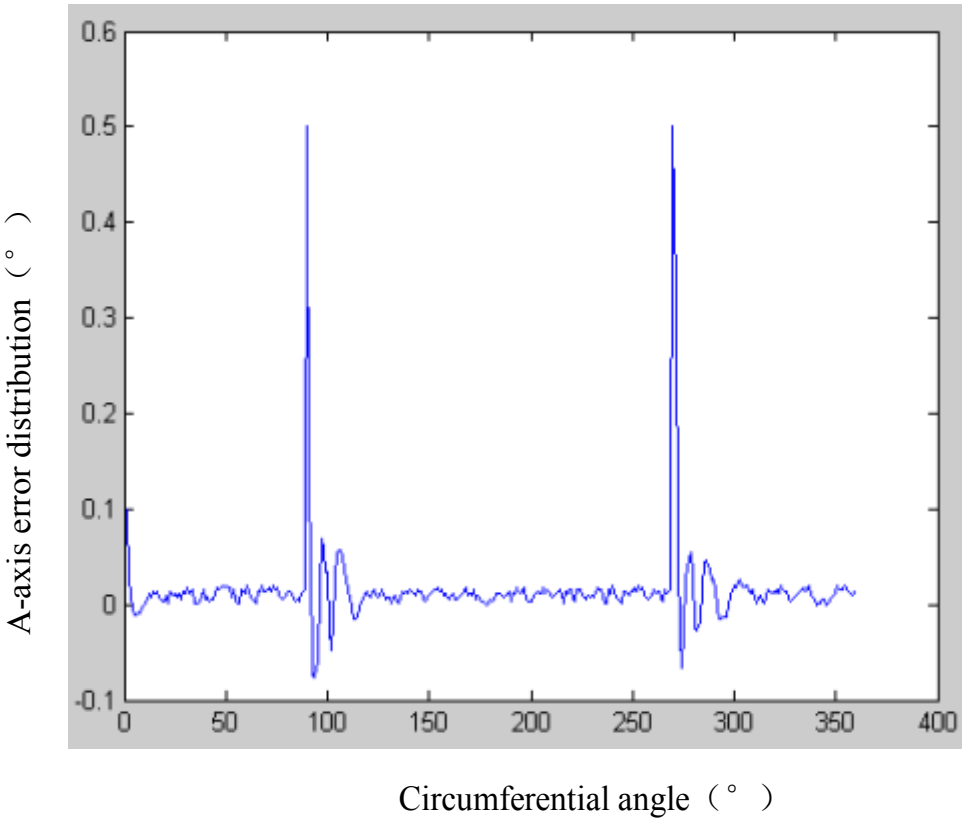


4. Fuzzy controller specific design

E	*EC*						
	NB	NM	NS	ZE	PS	PM	PB
NB	NB	NB	NB	NB	NM	ZE	ZE
NM	NB	NB	NB	NB	NM	ZE	ZE
NS	NS	NS	NS	NS	ZE	PS	PS
ZE	NS	NS	NS	ZE	PS	PS	PS
PS	NS	NS	ZE	PS	PS	PS	PS
PM	ZE	ZE	PM	PB	PB	PB	PB
PB	ZE	ZE	PM	PB	PB	PB	PB
				U			

According to the input and output fuzzy subsets of fuzzier, the fuzzy rules are established by using the conventional fuzzy conditions and the fuzzy relation "IF A AND B THEN C" to form the fuzzy algorithm which describes the control process.

5. Algorithm simulation calculation of fuzzy error compensation theory



Assuming that the speed of the tool swing is 1° /s, the interval between each calculation is the same as the NC interpolation time of coarse interpolation, is 10ms. Add a 0.5 ° output disturbance at 90 ° and 270 ° respectively. The corresponding error response results are shown in Fig.3. Through the simulation analysis of Matlab, the tool attitude is adjusted to 20 degree angle to the surface normal line of the sample.

- Fig. 3 Simulation of fuzzy error compensation for A axis

6. Verification of the processing experiment of the algorithm

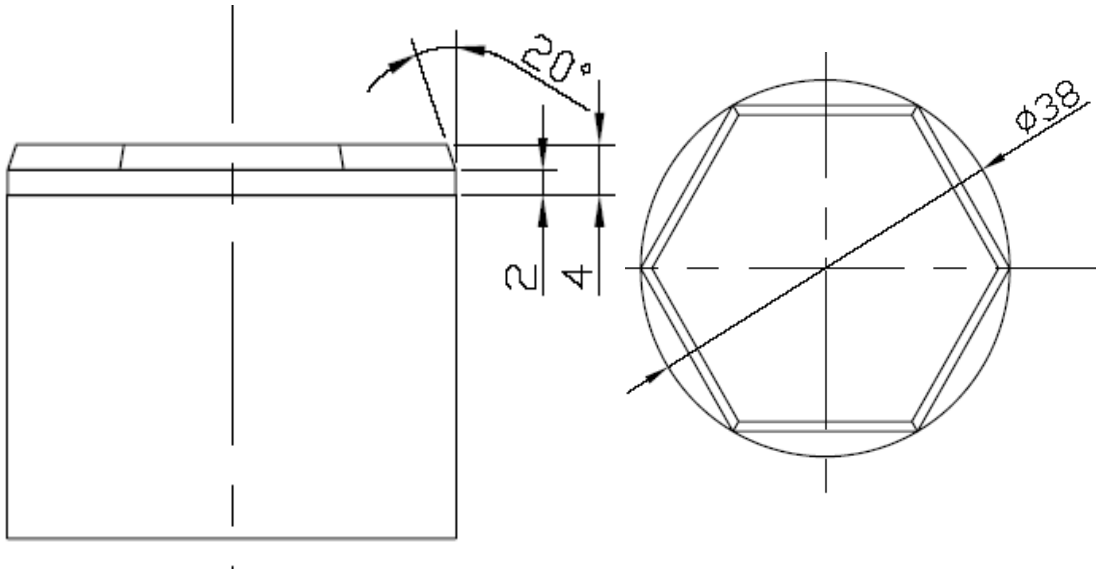


Fig.4 Sketch of the typical sample

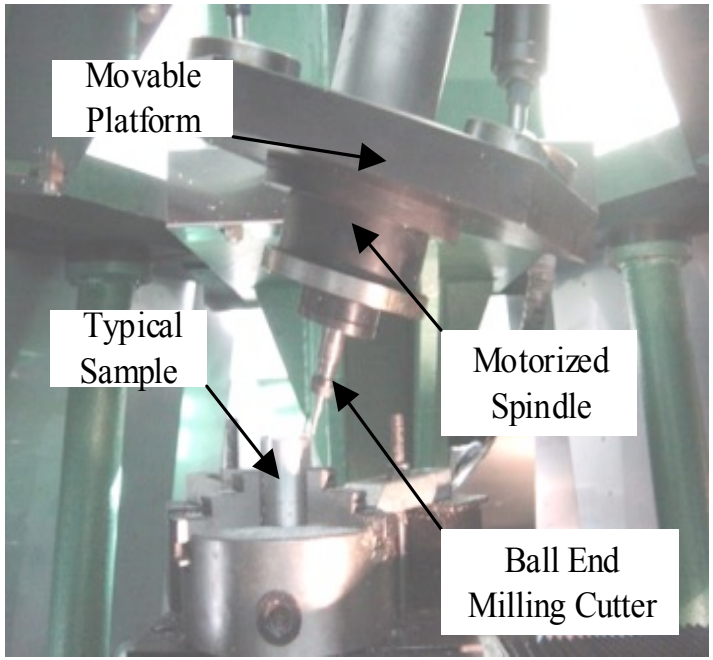


Fig.5 Chamfer cutting under the compensation

- In three conditions, the sample is processed under the condition of uncompensated, real axis compensation and virtual -real biaxial compensation, and the actual chamfering angle data of the after processing are shown in table2. The machining accuracy of the machine is greatly improved after the virtual-real biaxial error compensation is adopted.

Table2 Comparison of compensation for sample processing (Unit: °)

Measure Angle	30°	90°	150°	210°	270°	330°
Uncompensated	20.67	20.75	20.39	20.64	20.75	20.73
Compensated by real axis	20.31	20.27	20.28	20.39	20.17	20.31
Compensated by both Real and virtual axis	20.08	19.88	20.09	20.11	20.07	20.04

7. Conclusions

1. In this paper, a new type of virtual-real biaxial NC based on parallel or hybrid mechanism is studied.
2. Fuzzy control strategy is discussed for NC error compensation, its effectiveness is verified by theoretical simulation.
3. The experiment were designed and processed before and after compensation to verify the effective of motioned error compensation method.

Thank you!