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Backstepping Synchronous Control of Simplified Supersonic Missile

Xinyu Wang

Institute of Science and Technology for opto-electronic information, Yantai University, Yantai

Abstract

A new kind of novel control method which is named backstepping synchronous control is firstly proposed in this paper. It is a kind of method that can applied in any general system as widely as PID control, variable structure control and any other control method. Synchronization was most frequently used in secure communication and else in the past, but here its concept was successfully used to construct a new control method. It is similar to model referenced adaptive control but it is still different from that. An auxiliary system with several virtual synchronous inputs and a real input is constructed to cope the uncertainties of original system. The synchronous inputs are designed to realize the synchronization between auxiliary system and original system. Since the real input is designed according to the auxiliary system without uncertainty by using backstepping method, so it is easy to design. Because the synchronous input is decoupling so it is easy to cope with uncertainties. In this paper, simplified supersonic missile system was taken as an example to show the design process and stability analysis of the new method. Also, it was compared with traditional PID control and backstepping control method. At last, detailed numerical simulations were done to testify the effectiveness of the proposed method.

Keyword: *Synchronous control, Backstepping control, Missile, Stability, Uncertainty*

1. Introduction

Synchronization was firstly observed by Huygens in 1673 when he researched on coupled pendulums. In fact, there are many kinds of synchronization phenomenon [1-10] in coupled systems with interaction. For example, fireflies blink at the same time although each of them is different from each other. They can realize synchronization by some kinds of interaction. And we realized that synchronization not only exists widely in all real life but also it is very useful such as synchronization in secure communication. But also some synchronizations are bad and should be avoided by human beings such as information jam of internet and step synchronization of soldiers when they walk across a bridge.

Now researches of synchronization with control theory mainly focus on the following two parts. One is synchronization and its application in communication systems [1-13]. There are many papers which studied adaptive synchronization or robust synchronization of chaotic systems with different structure, or with model uncertainties and unknown parameters. For example, M.T. Yassen [14] designed a adaptive synchronization controller for a new kind of chaotic systems by using Lyapunov stability theory. This method can only used for chaotic system with unknown parameters, but the driving system should has the same structure as the response system.

Yongguang Yu [15] studied the synchronization of two kinds uncertain chaotic system with different structure but his method can only be applied for a kind of special system which can be transferred to a strict feedback system with uncertain nonlinear functions and unknown parameters.

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Awad El-Gohary [16] and Qiang Jia [17] also studied synchronization of uncertain chaotic systems with adaptive method and Lyapunov functions, but the uncertainties considered were mainly focused on linear uncertainties or unknown parameters.

Ju H. Park [18] proposed a kind of feedback synchronization by using both Lyapunov stability theory and LMI method. Xianyong Wu [19] realized adaptive synchronization of chaotic systems that master system has a structure different from slave system. But complex uncertainties are not considered in above researches.

Another part is focus on the synchronization of networks with complex dynamics. Those researches are very effective for networks with known structure and known parameter or known coupled functions. And it is more difficult to realize synchronization of two networks with unknown parameters or network structure. Some researchers tried to use adaptive method or robust method to achieve synchronization. So there are many papers about robust synchronization or adaptive synchronization of complex networks.

With the study of references above, it is obvious that the system uncertainties are the main difficult problem of both above two kinds of research work about synchronization [20-24]. Many kinds of uncertainties are studied and the most serious situation is those systems with nonlinear uncertainties which can not be described by bounded linear functions. So generally speaking, the main problem of above synchronization can be transferred to be a control problem. Also system with uncertainties is the main problem that designers should consider and solve.

There is another common point of above two kinds of researches which is easy to be neglected by readers is that all above synchronization problems can be defined as a controller design and stability analysis problem of high order system with multi-inputs [25-29]. In fact, there are only a few papers tried to use single input to realize synchronization of two high order systems. It is worthy pointing out that it is more difficult to realize synchronization of high order system with single input than to realize it with multi-inputs. Also, if we consider the situation that some states of system can not be measured, the question can be more difficult.

In this paper, a new kind of synchronization control method is firstly defined and proposed. Synchronization is used to control uncertain supersonic missile system with single input, so it is difficult. This synchronization control method is the same as PID control, adaptive control and variable structure control and other general control method that can be used for a common control system. Also, this method can be completely applied in above chaotic synchronization problem and complex networks.

A kind of novel auxiliary synchronous system is constructed to cope with the uncertainties of supersonic missile system. This novel control structure is similar but different to referenced model control method. The original system is uncertain and the auxiliary system is certain. The synchronization of above two systems is realized by constructing multi-virtual synchronous controls which are also designed to cope with uncertainties of original system. Those multi-virtual synchronous controls are decoupling for missile system so it is easy to design. And the real control law is designed according to an auxiliary system without uncertainties by using backstepping control method. So it is called backstepping synchronous control method. To make it simple and show the main principle of the new control method, the simplified supersonic missile system is taken for an example and the whole design procedure and stability analysis are given in this paper. At last, detailed simulations and comparison among PID control, backstepping control and backstepping synchronization control are done to show the rightness of the new method.

2. Problem Description

The simplified linear model of supersonic missile pitch channel can be written as following second order system:

$$\dot{\alpha} = \omega_z - a_{34}\alpha - a_{35}\delta_z \tag{1}$$

$$\dot{\omega}_z = a_{24}\alpha + a_{22}\omega_z + a_{25}\delta_z \tag{2}$$

where a_{ij} is air dynamic coefficient of missile, α is attack angle of missile, ω_z is the rotate speed of pitch angle and.

The control objective is to design a control law such that the attack angle α can track the desired angle α^d. Without loss of generality, assume $\alpha^d = 1$.

3. PID Control Law Design

The structure of PID control is showed as following figure 1. The system is constructed by PID controller and control object. And the object is controller by PID controller which is consisted by proportional item, differential item and integral item.

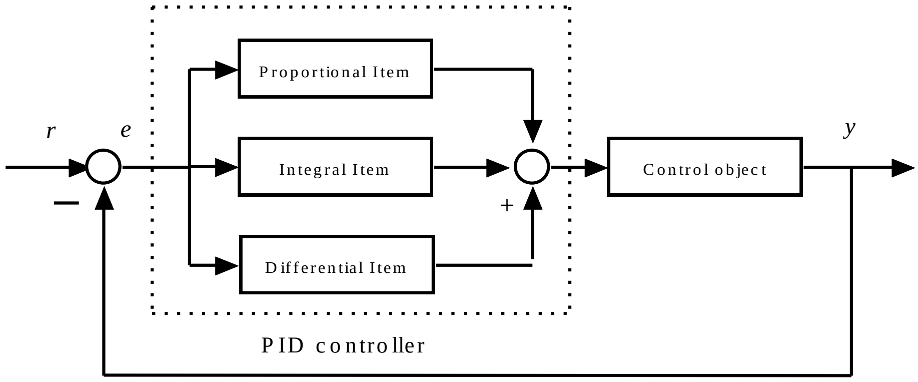

Figure 1. Structure of PID Control System

PID controller is a kind linear controller, it is composed by the error signal defined by the difference between the desired value x_1^d and output of system x_1 as follows:

$$e(t) = x_1 - x_1^d \tag{3}$$

The PID control law is designed as

$$u(t) = k_p\left(e(t) + \frac{1}{T_I}\int_0^t e(t)dt + \frac{T_D e(t)}{dt}\right) \tag{4}$$

It can be written as a transfer function as

$$G(s) = \frac{U(s)}{E(s)} = k_p\left(1 + \frac{1}{T_I s} + T_D s\right) \tag{5}$$

Where k_p is the coefficient of proportional item and T_I is the coefficient of integral item and T_D is the coefficient of differential item.

4. Backstepping Law Design

Consider the first subsystem as follows:

$$\dot{\alpha} = \omega_z - a_{34}\alpha - a_{35}\delta_z \tag{6}$$

Define a new error variable as $e_\alpha = \alpha - \alpha^d$, then

$$\dot{e}_\alpha = \omega_z - a_{34}\alpha - a_{35}\delta_z \tag{7}$$

Use the backstepping method to design the expected value of ω_z as

$$\omega_z^d = -k_1 e_\alpha - \hat{k}_2 + a_{35}\delta_z \tag{8}$$

Where $\hat{k}_2$ is an adaptive item which is mainly used to approximate information related with a_{34} .

Solve its derivative, it holds

$$\begin{aligned} \dot{e}_\alpha &= \omega_z^d + e_\omega - a_{34}(e_\alpha + \alpha^d) - a_{35}\delta_z \\ &= -k_1 e_\alpha - \hat{k}_2 + e_\omega - a_{34}(e_\alpha + \alpha^d) \\ &= (-k_1 - a_{34})\ e_\alpha - a_{34}\alpha^d - \hat{k}_2 + e_\omega \end{aligned} \tag{9}$$

Where e_ω is defined as $e_\omega = \omega_z - \omega_z^d$, choose the adaptive turning law as

$$\dot{\hat{k}}_2 = k_2 e_\alpha \tag{10}$$

Consider the second order system as below

$$\dot{e}_\omega = a_{24}\alpha + a_{22}\omega_z + a_{25}\delta_z - \dot{\omega}_z^d \tag{11}$$

Design the adaptive control law as

$$a_{25}\delta_z = -\hat{a}_{24}\alpha - \hat{a}_{22}\omega_z + \dot{\omega}_z^d - k_3 e_\omega - k_4\int e_\omega dt \tag{12}$$

Since δ_z is contained in ω_z^d, so $\dot{\omega}_z^d$ has information of $\dot{\delta}_z$. $\dot{\omega}_z^d$ can be written as

$$\begin{aligned} \dot{\omega}_z^d &= -k_1\dot{e}_\alpha - \dot{\hat{k}}_2 + a_{35}\dot{\delta}_z \\ &= -k_1(\omega_z - a_{34}\alpha - a_{35}\delta_z) - k_2 e_\alpha + a_{35}\dot{\delta}_z \end{aligned} \tag{13}$$

then

$$\begin{aligned} a_{25}\delta_z &= -(\hat{a}_{24} - k_1 a_{34})\alpha - (\hat{a}_{22} + k_1)\omega_z \\ &\quad - k_2 e_\alpha + k_1 a_{35}\delta_z + a_{35}\dot{\delta}_z - k_3 e_\omega - k_4\int e_\omega dt \end{aligned} \tag{14}$$

Define

$$T = a_{25}\delta_z - k_1 a_{35}\delta_z - a_{35}\dot{\delta}_z \tag{15}$$

Design T as

$$T = -(\hat{a}_{24} - k_1 a_{34})\alpha - (\hat{a}_{22} + k_1)\omega_z - k_2 e_\alpha - k_3 e_\omega - k_4\int e_\omega dt \tag{16}$$

Design the turning law of unknown parameters as

$$\dot{\hat{a}}_{24} = k_5 e_\omega \alpha \tag{17}$$

$$\dot{\hat{a}}_{22} = k_6 e_\omega \omega_z \tag{18}$$

Finally, solve control law according to transfer function method as

$$\delta_z = \frac{T}{-a_{35}s + a_{25} - k_1 a_{35}} \tag{19}$$

Where s means differential item and k_1 should be chosen properly such that above transfer function is stable. It is easy to prove the system with above control law is stable by chosen a Lyapunov function.

5. Backstepping Synchronous Method

Since there are many kinds of second order systems, it is very important that the same controller can be applied to many different second order systems. So it is meaningful to design a universal synchronous system that it is effective to all kinds of second order system.

So a kind of synchronous control method is proposed to solve this problem and it is a kind of universal method with structures as follows:

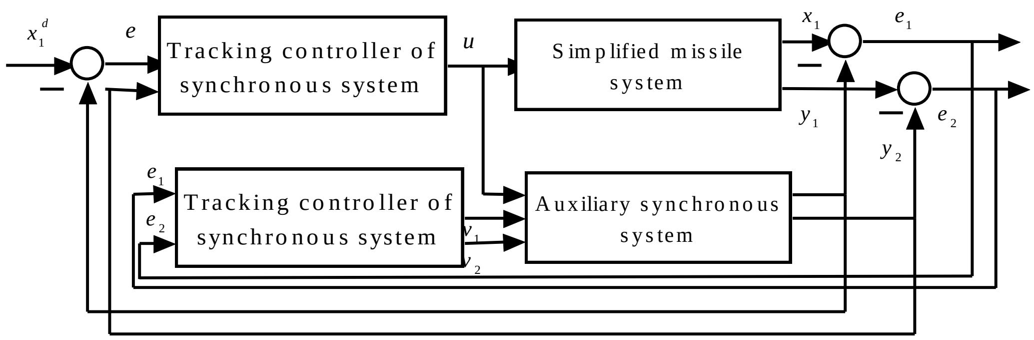

Figure 2. Structure of Synchronous Control

Construct an auxiliary system which has the same structure as the original simplified supersonic missile system as below:

$$\dot{\hat{\alpha}} = b_{11}\hat{\alpha} + b_{12}\hat{\omega}_z - a_{35}\delta_z + v_1 \tag{20}$$

$$\dot{\hat{\omega}} = b_{21}\hat{\alpha} + b_{22}\hat{\omega}_z + a_{25}\delta_z + v_2 \tag{21}$$

Where $v_i\,(i = 1,2)$ are synchronous control and $b_{ij}\,(i = 1,2,\ j = 1,2)$ are parameters of synchronous system.

The main reason to construct an auxiliary system is to design a synchronous control law and chose parameters $b_{ij}\,(i = 1,2,\ j = 1,2)$ such that states of synchronous system can track states of original system. So if the synchronous system can track the desired value α^d, then the attack angle of original system can track the desired value α^d.

Define error variables as

$$e_\alpha = \hat{\alpha} - \alpha \tag{22}$$

$$e_\omega = \hat{\omega} - \omega \tag{23}$$

And its derivative can be solved as follows:

$$\dot{e}_\alpha = \dot{\hat{\alpha}} - \dot{\alpha} \tag{24}$$

$$\dot{e}_\omega = \dot{\hat{\omega}}_z - \dot{\omega}_z \tag{25}$$

And it can be rewritten as

$$\dot{e}_\alpha = b_{11}\hat{\alpha} + b_{12}\hat{\omega}_z + v_1 + a_{34}\alpha - \omega_z \tag{26}$$

$$\dot{e}_\omega = b_{21}\hat{\alpha} + b_{22}\hat{\omega}_z + v_2 - a_{24}\alpha - a_{22}\omega_z \tag{27}$$

Then the main question is how to design synchronous law $v_i\,(i = 1,2)$ and parameter $b_{ij}\,(i = 1,2,\ j = 1,2)$ such that $e_i \to 0\,(i = \alpha, \omega)$, and two systems can have the same performance.

The synchronous control law can be designed as follows:

$$v_1 = -k_{p1}e_\alpha - k_{s1}\int e_\alpha dt \tag{28}$$

$$v_2 = -k_{p2}e_\omega - k_{s2}\int e_\omega dt \tag{29}$$

Choose a Lyapunov function as

$$V = \tfrac{1}{2}e_\alpha^2 + \tfrac{1}{2}e_\omega^2 \tag{30}$$

Solve its derivative as

$$\begin{aligned} \dot{V} &= e_\alpha \dot{e}_\alpha + e_\omega \dot{e}_\omega \\ &= -k_{p1}e_\alpha^2 - k_{p2}e_\omega^2 - k_{s1}e_\alpha\int e_\alpha dt - k_{s2}e_\omega\int e_\omega dt \\ &\quad + e_\alpha(b_{11}\hat{\alpha} + b_{12}\hat{\omega}_z + a_{34}\alpha - \omega_z) + e_\omega(b_{21}\hat{\alpha} + b_{22}\hat{\omega}_z + v_2 - a_{24}\alpha - a_{22}\omega_z) \end{aligned} \tag{31}$$

Choose k_{p1} and k_{p2} to be big enough positive numbers, then the error system can be proved to be stable according to the Lyapunov stability theorem.

Consider for the first order subsystem of auxiliary system

$$\dot{\hat{\alpha}} = b_{11}\hat{\alpha} + b_{12}\hat{\omega}_z - a_{35}\delta_z + v_1 \tag{32}$$

Define a new error variable $z_\alpha = \hat{\alpha} - \hat{\alpha}^d$ as

$$\dot{z}_\alpha = b_{11}\hat{\alpha} + b_{12}\hat{\omega}_z - a_{35}\delta_z + v_1 \tag{33}$$

Use backstepping method to design the desired value of $\hat{\omega}_z$ as

$$\hat{\omega}_z^d = -k_1 z_\alpha + a_{35}\delta_z / b_{12} - v_1 / b_{12} - b_{11}\alpha^d / b_{12} \tag{34}$$

Substitute it into equation 31

$$\begin{aligned} \dot{z}_\alpha &= b_{11}z_\alpha + b_{11}\alpha^d + b_{12}z_\omega + b_{12}\omega_z^d + v_1 - a_{35}\delta_z \\ &= b_{11}z_\alpha + b_{11}\alpha^d + b_{12}z_\omega + b_{12}(-k_1 z_\alpha + a_{35}\delta_z / b_{12} - v_1 / b_{12} - b_{11}\alpha^d / b_{12}) + v_1 \\ &= (b_{11} - b_{12}k_1)z_\alpha + b_{12}z_\omega \end{aligned} \tag{35}$$

Define

$$\overline{k}_1 = b_{11} - b_{12}k_1 \tag{36}$$

It is obvious that there exists a big enough k_1 such that $\overline{k}_1 < 0$, then it holds

$$\dot{z}_\alpha = \overline{k}_1 z_\alpha + b_{11}\alpha^d + b_{12}z_\omega \tag{37}$$

For the second order system, it holds

$$\dot{z}_\omega = b_{21}\hat{\alpha} + b_{22}\hat{\omega}_z + a_{25}\delta_z + v_2 - \dot{\hat{\omega}}_z^d \tag{38}$$

Design adaptive control law as

$$\delta_z = \frac{1}{a_{25}}(-v_2 + \hat{\omega}_z^d) - k_2 z_\omega - k_3\int z_\omega dt \tag{39}$$

Where $k_1 = 30, k_2 = 50, k_3 = 10$. And for equation 37, it holds

$$\dot{z}_\omega = -k_2 z_\omega - k_3\int z_\omega dt \tag{40}$$

Choose a Lyapunov function as $V_1 = \frac{1}{2}k_3\left(\int z_\omega dt\right)^2$ (41)

Then

$$\dot{V}_1 = k_3 z_\omega \int z_\omega dt \tag{42}$$

Choose

$$V_2 = \frac{1}{2} z_\alpha^2 + \frac{1}{2} z_\omega^2 \tag{43}$$

Then

$$\dot{V}_2 = z_\alpha \dot{z}_\alpha + z_\omega \dot{z}_\omega \tag{44}$$

Choose a whole Lyapunov function for the whole system as:

$$V = V_1 + V_2 \tag{45}$$

Then

$$\begin{aligned} \dot{V} &= k_3 z_\omega \int z_\omega dt + z_\alpha \dot{z}_\alpha + z_\omega \dot{z}_\omega \\ &= \bar{k}_1 z_\alpha^2 + b_{12} z_\alpha z_\omega - k_2 z_\omega^2 \end{aligned} \tag{46}$$

And it can be reduced by using a inequality as

$$\dot{V} \le \bar{k}_1 z_\alpha^2 + \frac{1}{2} b_{12} z_\alpha^2 + \frac{1}{2} b_{12} z_\omega^2 - k_2 z_\omega^2 \tag{47}$$

It is obvious that if big enough positive k_1 and k_2 are chosen, it has $\dot{V} \le 0$, then the system can be proved to be stable according to Lyapunov stability theorem.

6. Numerical Simulation

Air dynamic parameters of a special height of supersonic missile is chosen for simulation as follows:

$$a_{25} = -167.87; a_{35} = 0.243; a_{22} = -2.876; a_{24} = -193.65; a_{34} = 1.584$$

Those parameters comes from experiment data of wind tunnel, so it may be not very accurate. Because of that the uncertainties are considered in the below simulation and all dynamic parameters are 50% or even 500% different form the standard value.

6.1. Simulation of PID Control

Choose PID control parameters as

$$k_p = 2, k_i = 5, k_d = 5$$

First, consider the situation that there are no uncertainty and the system parameters are accurate, then the simulation result are showed as follows:

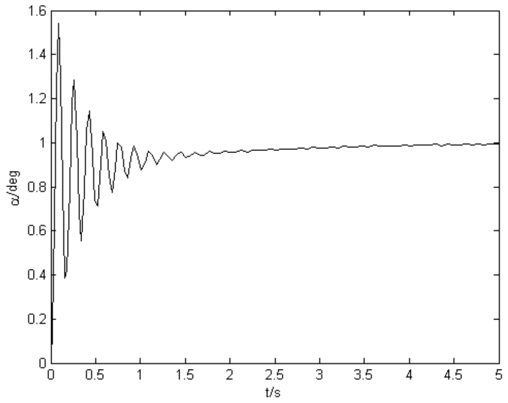

Figure 3. Result PID Control of System without Uncertainty

And consider the situation with uncertainties, and uncertainties are defined by k , then air dynamic parameters are defined as

$$A_{22} = a_{22} \cdot (1 + k); \quad A_{24} = a_{24} \cdot (1 + k); \quad A_{25} = a_{25} \cdot (1 + k);$$

$$A_{34} = a_{34} \cdot (1 + k); \quad A_{35} = a_{35} \cdot (1 + k)$$

And desired single are 1, the simulation result are shown as follows:

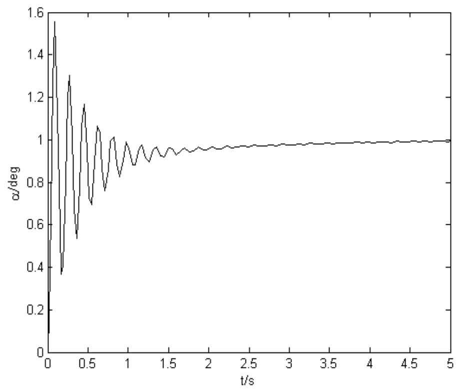

Figure 4. Result of $k = -10\%$

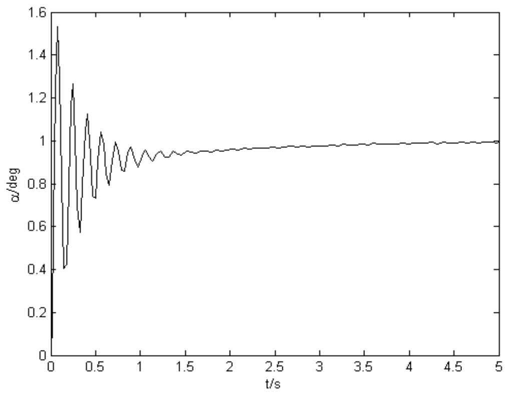

Figure 5. Result of $k = 10\%$

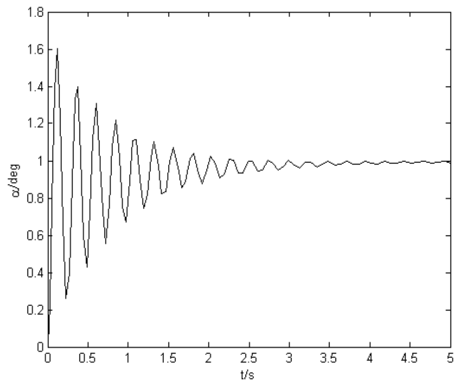

Figure 6. Result of $k = -50\%$

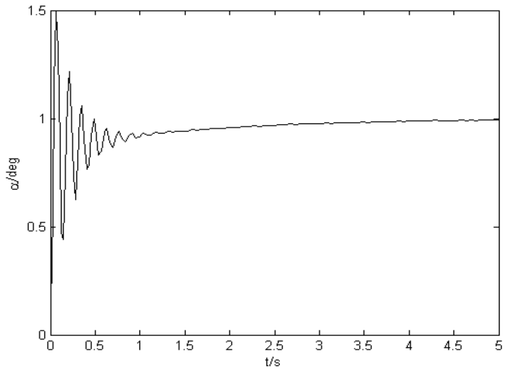

Figure 7. Result of $k = 50\%$

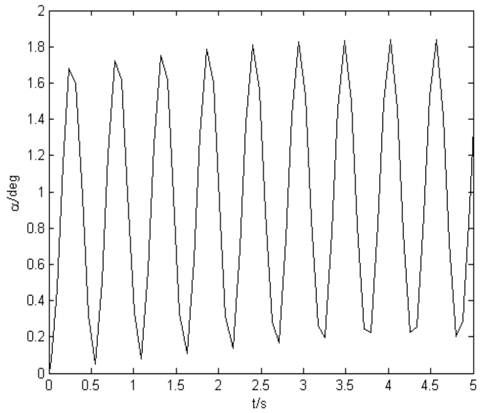

Figure 8. Result of $k = -90\%$

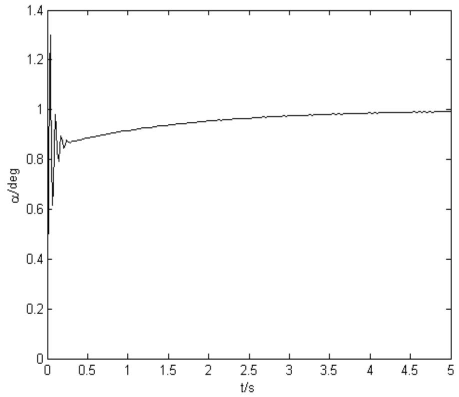

Figure 9. Result of $k = 500\%$ Set rand variable K_s as

$$k_s = 2K * (\mathrm{rand}(5,1) - 0.5)$$

Where function rand produce a rand number in interval (0, 1) , and $k_{s1}, k_{s2}, k_{s3}, k_{s4}$ and k_{s5} are rand number with the same characteristics as K_s, and matrix A is determined as follows:

$$A_{22} = a_{22} \cdot (1 + k_{s1}); A_{24} = a_{24} \cdot (1 + k_{s2}); A_{25} = a_{25} \cdot (1 + k_{s3});$$

$$A_{34} = a_{34} \cdot (1 + k_{s4}); A_{35} = a_{35} \cdot (1 + k_{s5}).$$

And simulation result of PID control are shown as below Figures:

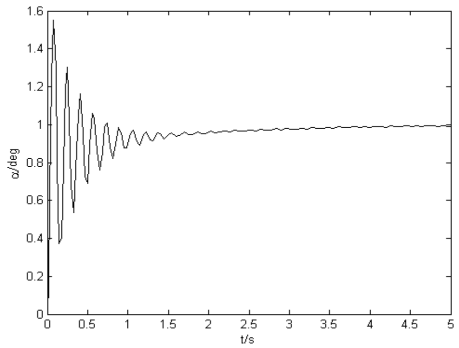

Figure 10. Result of $k_s \in (-10\%, 10\%)$

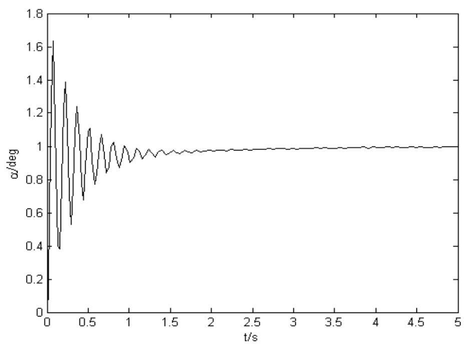

Figure 11. Result of $k_s \in (-50\%, 50\%)$

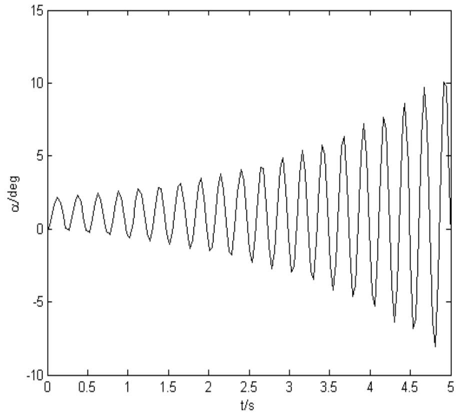

Figure 12. Result of $k_s \in (-90\%, 100\%)$

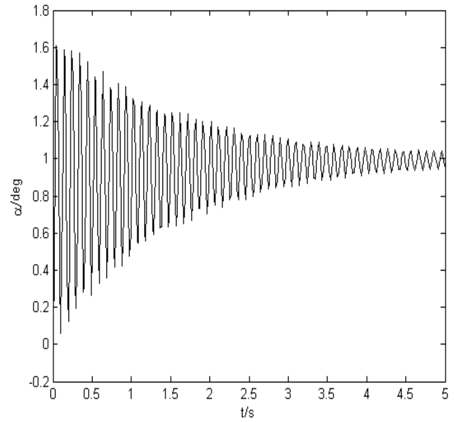

Figure 13. Result of $k_s \in (-90\%, 500\%)$

The simulation result shows that if the uncertainties are not very big, the system can be stable with PID control; but if the uncertainties are increase, then the system will be unstable with PID control.

6.2. Simulation of Backstepping Control

Choose control parameters as below:

$$c = 2, d = 5, k_1 = 20, k_2 = 30, k_3 = 20, b = 1, k_{p1} = k_{p2} = 25, k_{s1} = k_{s2} = 32 .$$

First consider the situation of backstepping control with uncertainties which is defined by K as below:

$$A_{22} = a_{22} \cdot (1 + k);\ A_{24} = a_{24} \cdot (1 + k);\ A_{25} = a_{25} \cdot (1 + k);$$

$$A_{34} = a_{34} \cdot (1 + k);\ A_{35} = a_{35} \cdot (1 + k)$$

The desired value is 1 and simulation result is shown as following Figures:

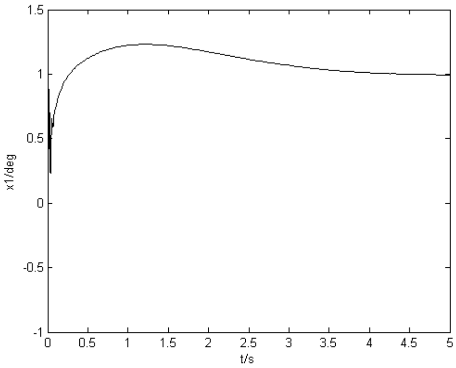

Figure 14. Result of no Uncertainty

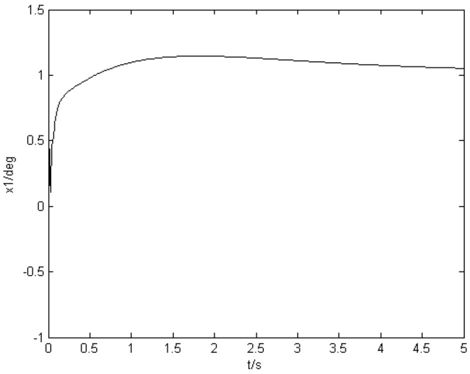

Figure 15. Result of $k = -5\%$

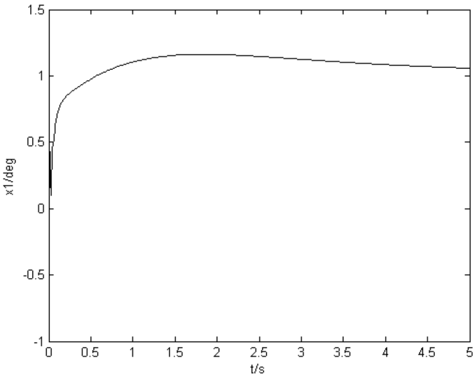

Figure 16 Result of $k = 5\%$

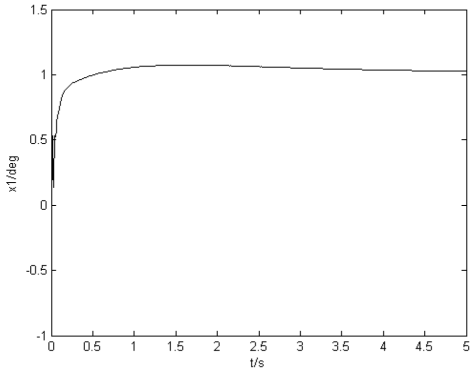

Figure 17 Result of $k = -50\%$

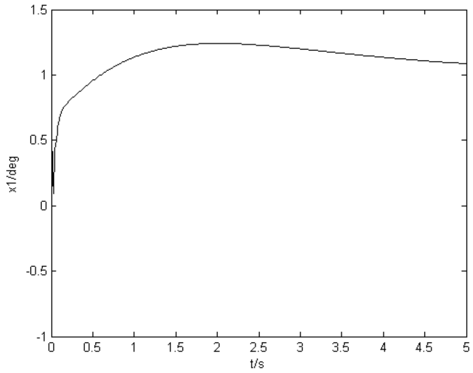

Figure 18 Result of $k = 50\%$

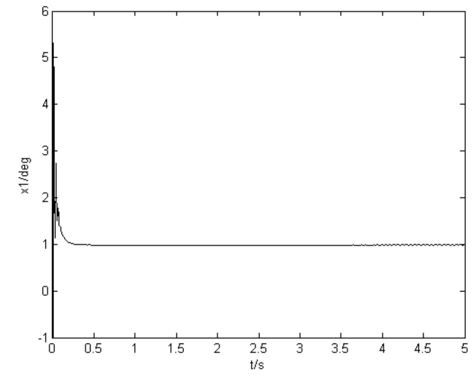

Figure 19 Result of $k = -90\%$

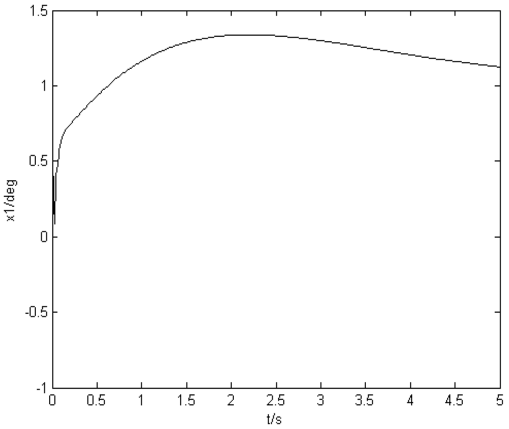

Figure 20. Result of $k = 100\%$

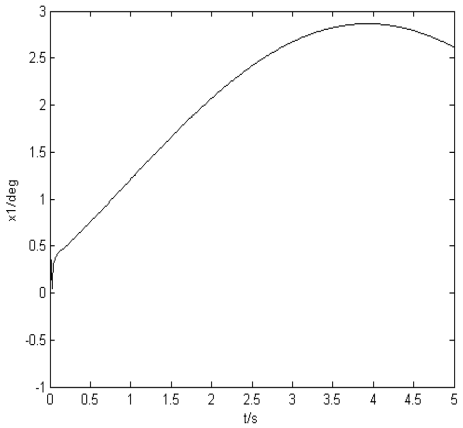

Figure 21. Result of $k = 500\%$

Also, we use the same characteristic parameters of supersonic missile and set rand variable K_s as

$$k_s = 2K * \left(rand\left(5,1\right) - 0.5\right)$$

Where rand function produce a rand number in interval (0, 1) , and $k_{s1}, k_{s2}, k_{s3}, k_{s4}$ and k_{s5} are rand number with the same characteristics as K_s, and matrix A is determined as follows:

$$A_{22} = a_{22} \cdot (1 + k_{s1}); A_{24} = a_{24} \cdot (1 + k_{s2}); A_{25} = a_{25} \cdot (1 + k_{s3});$$

$$A_{34} = a_{34} \cdot (1 + k_{s4}); A_{35} = a_{35} \cdot (1 + k_{s5}).$$

The desired value is 1 and the simulation result is shown as below:

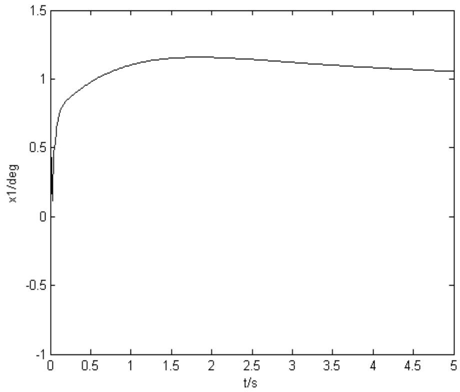

Figure 22. Result of $k_s \in (-5\%, 5\%)$

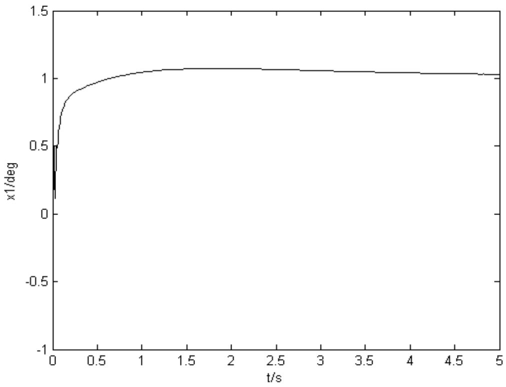

Figure 23. Result of $k_s \in (-50\%, 50\%)$

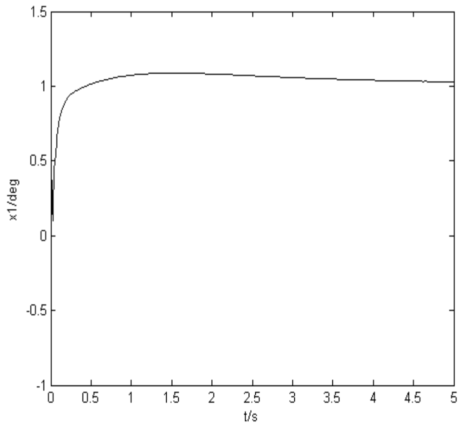

Figure 24. Result of $k_s \in (-100\%, 100\%)$

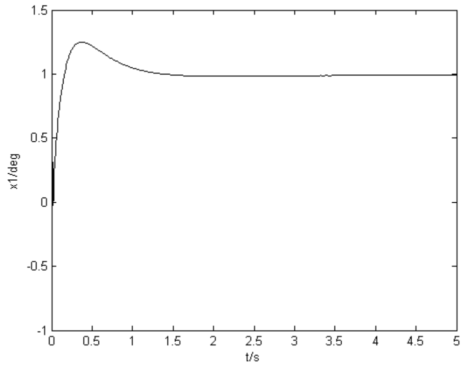

Figure 25. Result of $k_s \in (-500\%, 500\%)$

Above Figures shows that the system is always stable but the settle time is too long in some situation.

6.3. Simulation of Backstepping Synchronous Control

Choose control parameters of synchronous control as below

$$c_1 = 8, c_2 = 5, q_1 = 1, q_2 = 1, q_3 = 1, k_1 = 20, k_2 = 20, k_3 = 20$$

Use the same method to simulate uncertainties as above, the simulation result is shown as follows:

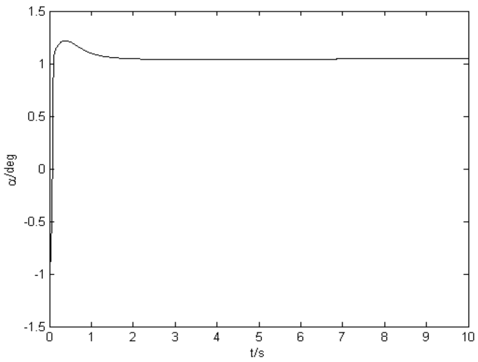

Figure 26. Result of no Uncertainty

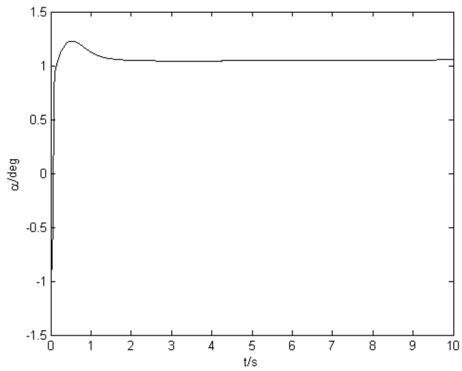

Figure 27. Result of $k = -5\%$

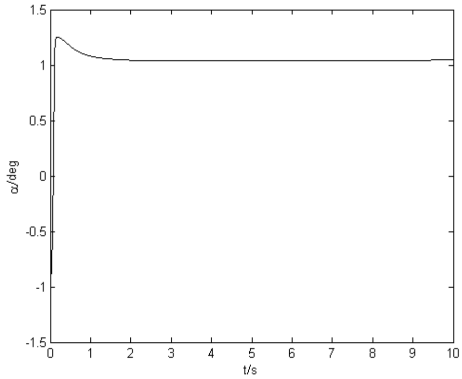

Figure 28. Result of $k = 5\%$

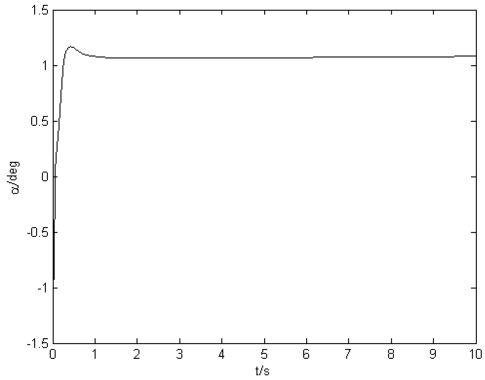

Figure 29. Result of $k = -50\%$

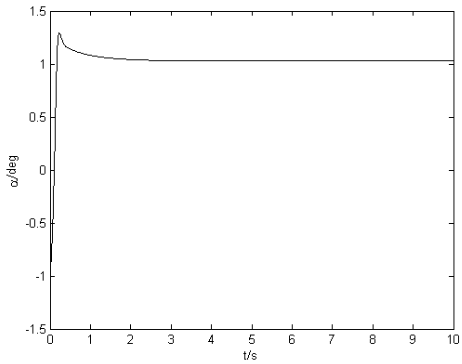

Figure 30. Result of $k = 50\%$

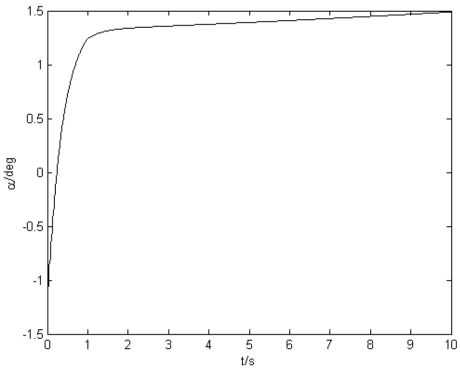

Figure 31. Result of $k = -90\%$

So the simulation results are stable for all situations and set $k_s = 2K * \left(rand\left(5,1\right) - 0.5\right)$, and matrix A is determined as above, the simulation result is shown as following Figures:

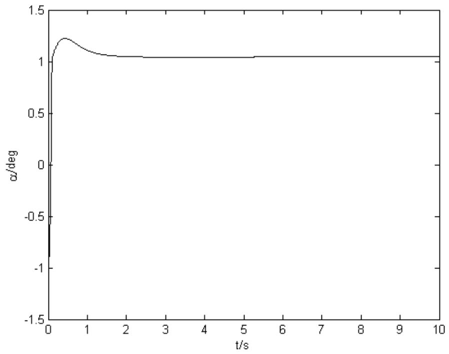

Figure 32. Result of $k_s \in (-5\%, 5\%)$

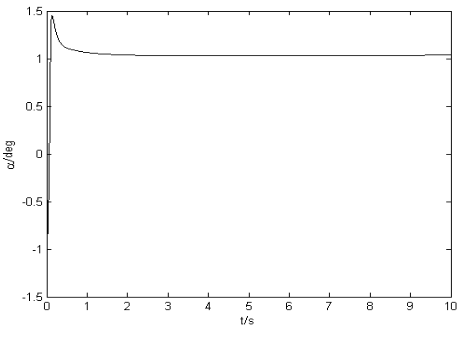

Figure 33. Result of $k_s \in (-50\%, 50\%)$

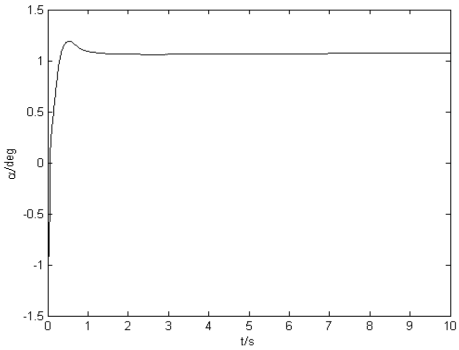

Figure 34. Result of $k_s \in (-100\%, 100\%)$

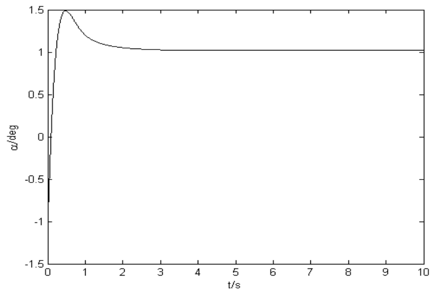

Figure 35. Result of $k_s \in (-500\%, 500\%)$

All simulation results are stable and it means that the synchronous method has good robustness.

6.4 Analysis of Simulation

The above simulation results shows that all three methods can make the missile system stable in some characteristic height with consideration of small uncertainties. But if the uncertainties increase, the PID control is not effective and especially if the uncertainties are random, the control effect of PID control is not as good as backstepping control. And both backstepping control and synchronous control are stable but the synchronous control method has better robustness and it is not necessary to know the system parameter in advance.

7. Conclusions

A kind of new synchronous control method, which is mostly used in synchronization of secrete communication in the past research papers, is firstly proposed in this paper to control the random uncertain missile systems of pitch channel. Also PID control, backstepping control and synchronous control method are researched and compared with application of the same control object. Simulation result shows that the synchronous backstepping method is an effective new method with strong robustness and it also has a advantage that it is a universal method without knowing the model parameters in advance.

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Author

Xinyu Wang, she was born in Yantai, Shandong province of China in 1963.She received the B. Eng degree in Physics from Liaocheng Normal College in 1985. She received the Master Degree in System Science from Naval Aeronautical Astronautical University, Yantai of China in 2006. After that she continued her study there and received the Doctor degree in Communication and Information System in 2010.

She worked as a teacher in Yantai University in Shandong province of China in 1985 and was promoted to be a vice professor in 1999 and became a professor in 2008. Now her present interests are chaotic system, communication, physics and information.