ISSN : 0974 - 7435 Volume 8 Issue 7

BioTechnology
An Indian Journal
FULL PAPER
BTAIJ, 8(7), 2013 [1015-1018]

The present situation of research on iterative learning control

Hao Xiaohong[1]*, Gu Qun[2], Ju Yuanyuan[2], Wanghua[2]
[1]College of computer and communiction, Lanzhou University of Technology, Lanzhou 730050, (CHINA)
[2]School of Electrical and Information Engineering, Lanzhou University of Technology, Lanzhou 730050, (CHINA)

ABSTRACT

This paper introduces the current research situation of iterative learning control algorithms, first gives the traditional iterative learning control algorithm. We presented the research status of convergence of iterative learning control algorithms, the iterative learning control of some typical algorithms and industrial production combined with examples.

KEYWORDS

Optimization methods;
Iterative learning control;
Survey;
Convergence.

INTRODUCTION

Control problems can be divided into two kinds, namely the regulation and tracking problems. But the regulation problem can be considered as a special case of the tracking problem is. Then, we discussed in the [0,T] the output tracking problem. If the object model is known exactly and reversible, then there is no doubt that this will become extremely simple. However, after all, this is only a theoretical situation, is simply not possible in reality. Another method is widely applied and feasible is to use the idea of feedback controller, through a variety of to achieve the desired output tracking. But this regulation also can achieve asymptotic tracking of a desired output trajectory. Whether they can find a good way, to achieve complete tracking of the output trajectory of [0,t] over a period of time?

Arimoto et al in 1984 formally put forward iterative learning control (ILC) method of[1], the thought to be perfect, a practical algorithm, and proves the effectiveness of this algorithm, creates a new research direction.

Iterative learning control is a control technique of artificial intelligence combined with automatic control, has a strict mathematical description of the branch of intelligent control, is a research, development and application of intelligent control in the field of one of the most important development direction of [2,3]. Its goal is to achieve the perfect tracking over a finite interval. It is through the control on the system to attempt, modify the system deviation of output and the desired continuous control input signal, so that the tracking performance of the system is improved, which is seeking to control system to input, the controlled object trajectories in the finite time interval [0, T] along the desired trajectory to achieve zero error complete follow-up, namely the deviation between the actual output and the expected output of the system is zero, and the whole process completed quickly.

Iterative learning control is the output of error control input signal current in the system generated in the iterative learning control, learning rate, produces the control input signal next, again acting on the system, repeatedly, so that the output error between the actual output and the expected output is zero.

The advantages of iterative learning control can be in a very simple way and requires less a priori knowledge to deal with uncertain dynamic system with a very high degree, parameters of controller need't identify system during operation, which belongs to the self learning control based on[4] quality, and iterative learning control with memory function, can quickly adjust the control signal according to the memory the information in the system. Figure 1 is Iterative learning control schematic diagram.

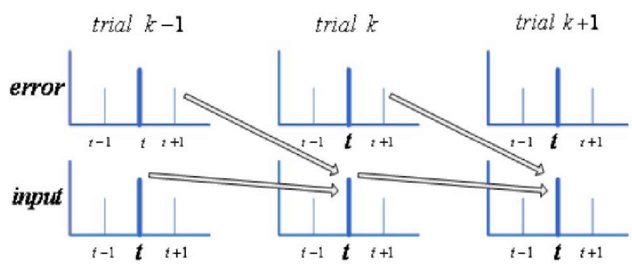

Figure 1 : Iterative learning control schematic diagram

The basic principle of iterative learning control as shown in Figure 2, in practical application, a new control variable system the next operation can be calculated off-line at the end of the last run, can also be calculated online in the last run; a new control variable is stored in memory, control the amount of brush new; when a control, control the amount of memory required to obtain from. As you can see, the iterative learning control algorithm can make use of information than the conventional feedback control algorithm, which includes before the time of running all the time the information.

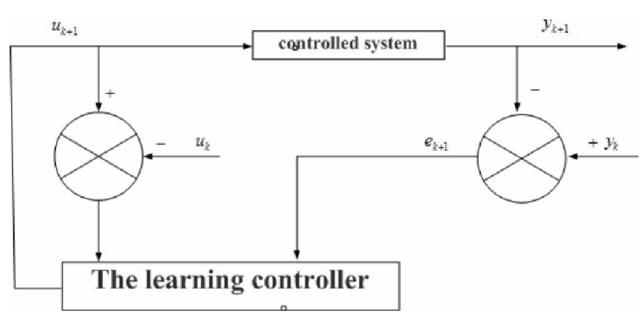

Figure 2 : The structure of iterative learning control

In the traditional iterative learning control research, always assume the following assumptions:

(1) each time the system running time interval is fixed interval limited;

(2) the desired trajectory system is given and known;

(3) repeat the initial conditions of the system, namely before each run, the initial state of the system are the same;

(4) the dynamic structure of the system remains constant in each run;

(5) output system each run can be measured;

(6) and the ideal output control makes the system state and the output is expected to the existence and uniqueness of the.

However in the practical application, many dynamic system does not meet the above conditions, therefore, sometimes we have to reduce the requirements of precision tracking, and replaced by a more reasonable request: find the system input and the system output to the desired output.

DISCUSSED PROBLEMS

Traditional iterative learning control

The PID type iterative learning control algorithm can be described as:

$$u_{k+1}(t)=u_k(t)+\Gamma_P e_k(t)+\Gamma_i\int e_k(t)dt+\Gamma_D \dot{e}_k(t) \qquad \textbf{(1)}$$

Because of its algorithm is simple and effective, small amount of calculation, and only need little prior knowledge of systems, has been studied widely and deeply, is one of the iterative learning control algorithm is the most mature. Arimoto and its partner contributions in this aspect biggest, they first proposed learning control algorithm for D type[1], type PD and type PID[5] iteration, more importantly, they introduced norm this mathematical tool, the analysis has been to ensure the convergence of the iterative learning algorithm in terms of. This tool has become the basic means of learning control algorithm convergence of iterations.

Iterative learning control algorithm for fast convergence

Iterative learning control, not only to ensure the convergence of the algorithm, but also in the introduction of performance indicators, using an optimization method for design optimization iterative learning algorithm, the algorithm has fast convergence speed. As a result of their learning step with the deducing process in solving optimization objectives, but also in optimizing index, which has the best convergence rate, so the optimal iterative learning control law in the learning parameter selection and convergence rate advantage. For the actual controlled object, we can get the precise mathematical model. Therefore, the optimization design of iterative learning control method is very popular. Amann and Owens proposed for learning control algorithm for[20] optimization iterative linear discrete system, the tracking error convergence of monotone geometry. The algorithm is mainly through in each iterative process of solving an optimization problem, the optimal input and will be obtained on the object to achieve. In the premise of not affecting the convergence characteristics, looking for a small amount of computation and is easy to implement the algorithm, Owens, Fang and H ä t ö Nen proposed parameter optimal iterative learning control[6,7]. This method has the advantages of simple structure and retained the characteristics of tracking error converges monotonically, but most of them are only applicable to linear system. This is a great defect, because the dynamic systems in reality are often highly nonlinear. Hatzikos and Owens proposed a method based on the genetic algorithm (Genetic Algorithm:GA) learning control algorithm for GA-ILC[23] optimization iteration, and it has been proved that the method of the linear time invariant system with very good control effect. After that, Hatzikos, Owens and H ä t ö Nen is extended to[8,9,10] of this method, has obtained the good effect in nonlinear system control. But in this method, not the code useful prior information into the genetic algorithm, the search space is too large, coupled with the SGA search capability is not strong, eventually led to the overall slow convergence method.

Application of iterative learning control research

In view of the iterative learning control algorithm is superior to many, iterative learning control in industrial production line manipulator, NC machine tools[11], linear motor[12], plastic extrusion machine,[13,14] semiconductor wafer production process of batch processes, soaking furnace temperature control, stretch reducing process of seamless pipe wall thickness control, tobacco fermentation system control mechanism has the very good application. GU Qun, HAO Xiaohong put forward a algorithm. When de-icing robot performs the de-icing taskÿit must across all kinds of obstacles. The iterative time warping distance learning control algorithm is applied to the ice line robot manipulator trajectory tracking control system, in the implementation of the time, every time to solve the optimal problem is solved using EADTW distance, to optimize the traditional iterative learning control algorithm, the icing line robot manipulator trajectory tracking, solve the disadvantages of the traditional algorithm of real-time. Finally can be verified by simulation, this method can effectively achieve the complete tracking the trajectory of the robot manipulator icing line, and has good convergence[15].

CONCLUSIONS

Iterative learning control for repetitive movements characteristic of uncertain control system has good control effect, and its high accuracy, easy to approach the desired trajectory characteristics combined with other control method makes the application scope expanding, more and more important in the field of control status will be more.

ACKNOWLEDGEMENTS

This research was supported by The National Nature Science Foundation of China No.61263008 and natural science foundation of Gansu Province(No.1212RJYA031,No. 1112RJZA023 and No.1107RJZA150).

REFERENCES

[1] S.Arimoto, S.Kawamura, F.Miyazaki; Bettering operation of robots by learning [J]. Journal of Robotic Systems, **1(2)**, 123-140 **(1984)**.

[2] H.S.Ahn, C.H.Choi, K.B.Kim; Iterative learning control for a class of nonlinear systems[J]. Automatica, **29(6)**, 1575-1578 **(1993)**.

[3] N.Amann, D.H.Owens, E.Rogers; Iterative learning control for discrete-time systems with exponential rate of convergence[J]. IEE Proceedings-Control Theory and Applications, **143(2)**, 217-224 **(1996)**.

[4] N.Amann, D.H.Owens, E.Rogers; Robustness of norm-optimal iterative learning control[C]. Proceedings of IEE International Conference on Control, Exeter, UK, 1119-1124 **(1996)**.

[5] S.Arimoto, S.Kawamura, F.Miyazaki et al.; Learning control theory for dynamic systems[C]. Pro-

ceedings of the 24th IEEE Conference on Decision and Control, Lauderdale, Florida, 1375-1380 **(1985)**.

[6] N.Amann, D.H.Owens, E.Rogers; Robustness of norm-optimal iterative learning control [A]. Proceedings of IEE International Conference on Control [C], Exeter, UK, **1119-1124 (1996)**.

[7] D.H.Owens, D.H.Owens, K.Fang; Parameter optimization in Iterative Learning Control [J]. International Journal of Control, **76(11)**, 1059-1069 **(2003)**.

[8] D.H.Owens, J.Hätönen; Iterative Learning control-an optimization paradigm [J]. Annual Reviews in Control, **29**, 57-70 **(2005)**.

[9] V.Hatzilos, D.Owens; A Genetic Algorithm Based Optimization Method for Iterative learning Control Systems[C]. Proceedings of the 3th International Workshop on robot mutation and control, Poland, 423-428 **(2002)**.

[10] V.Hatzikos, D.H.Owens, Jari Hätönen; An Evolutionary Based Optimization Method for Nonlinear Iterative Learning Control Systems [A]. In: Proceedings of the American Control Conference [C], Denver, Colorado, 3415-3420 **(2003)**.

[11] K.S.Lee, K.K.Tan, S.Y.Lim, H.F.Dou; Iterative learning control of permanent magnet linear motor with relay automatic tuning [J]. Mechatronics, **10**, 169-190 **(2000)**.

[12] Y.Chen, C.Wen; Iterative learning control-Analysis, Design, Integration and Applications. London, Springer, **(1999)**.

[13] J.Y.Choi, H.M.Do; A learning approach of wafer temperature control in a rapid thermal processing system [J]. IEEE Transactions on Semiconductor Manufacturing, **14(1)**, 1-10 **(2001)**.

[14] K.S.Lee, I.S.Chen, H.J.Lee; Model predictive control technique combined with iterative learning for batch processes [J]. AIChE Journal, **45(10)**, 2175-2187 **(1999)**.

[15] Gu Qun, Hao Xiaohong; Tracking Control of Robot's Trajectory Based on DTW-ILC Algorithm[J]. Journal of Applied Sciences., **13(11)**, 2115-2118 **(2013)**.