Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2015, 7(1):892-896

Review Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Methods for closed loop system identification in industry

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ABSTRACT

In many case, open loop system identification is not feasible and practical. Closed loop identification is major role in such cases. For any closed loop system identification, there are some methods which are used to identify the closed loop system, including direct method, indirect method, two-stage method, joint input-output method. Using any one method we can identify the plant model. For designing of advance controller, the model of plant is very important. In this paper, summary of all closed loop identification methods are described in brief.

Keywords: System identification, closed-loop system identification, parameter estimation, process modeling.

INTRODUCTION

Identification is an exercise which is used for explaining the relation between the input and output of the system. Process model is used for design of controller, prediction, soft sensor, performance enhancement, fault detection etc. This process model can be derived using first principle or empirical modeling.

In closed loop identification data are collected from a closed loop test where a underlying process is fully under feedback control. When performing identification experiment on unstable system it is necessary to do this in closed loop with a controller. Another reason for considering closed loop identification might be that the system has to be controlled for economic and safety reason or that the intended model used is model based control design. System Identification is a method of developing mathematical model based on empirical data means based on input and output.

In most of case in identification is done in open-loop system means without having any feedback system. But in many cases, open-loop system is not practical because of safety and other concern. In this case, closed-loop system identification becomes important. The performance of closed loop system can be improved by a controller based on the identification model form the closed loop data[2].Main advantage of closed loop system having feedback in the system which is helpful for the plant or system to achieve good performance. Closed loop system is used because if the system is unstable we can't identify the open loop system [3].

This paper is organized as follow. In section 2 closed-loop system identification, needs of closed loop system and real-time closed-loop system identification is described. In section 3 is given literature review for system identification and in section 4 methods of closed-loop system identification are described , in section 5 conclusions are made for this paper and in last references are given for this work.

Closed Loop System Identification

Basically closed loop system are used to reduce the error in plant using the feedback control . The closed loop system is used to avoid undesirable product during identification process. Basic structure of closed loop system is shown in the fig (1) where a feedback is connected with controller and plant. Closed system are used because of the in any plant open loop system are give some undesirable product and loss.

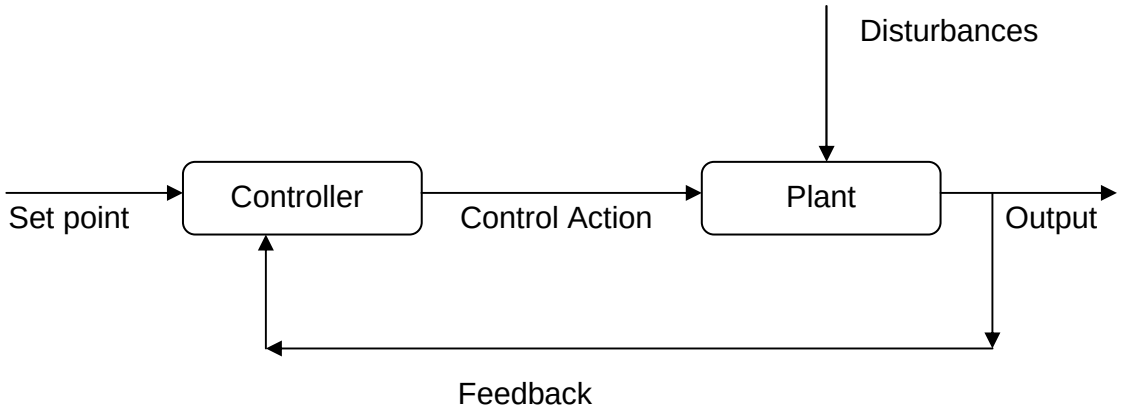

Fig 1 Closed Loop system with some disturbance in system

According to fig (1) there is a controller which give the input to the plant but there is a disturbance or unwanted signal are occurred in the plant which causes to some loss and undesirable product in the output but closed loop having feedback so if there more disturbance in the system it will return to the controller as input after checking all parameter it passes again to the plant and process is going on until the output will not satisfy.

1.1. Need of Closed loop system

For most of the system , open loop system for identification is used but in open loop system is not feasible and practical so that we can use closed loop system identification. Closed loop system is generally used for feedback control [1]. Need of closed loop are required when in open loop system sometimes gives error in the output than closed loop system are used. Closed loop have advantage of feedback which causes to less error in the output in the system. Closed loop system need is due to some reason-

1. When the system is not stable we can't identify the system or testing the open loop.
2. Restriction in quality in the plant for open loop system.
3. To improve the performance of the system.
4. To avoid undesirable product in plant and get good result in plant.
5. For open loop identification, we have to open the loop so resulting in financial loss due to high costs in time and manpower.
6. An important purpose of closed loop data is to make the closed loop system insensitive to changes in the open loop system.

1.2. Real Time Closed Loop Identification

For plant using any method we can identify the system but using real time process is quite and deserving challenge to identify the system. For real time process we can identify the system by the open loop data. For real time closed loop identification there are many challenges in the system which affects the system. The challenges are-

1. In closed loop system main problem is to correlation between the input and undesirable noise.
2. For Some method to identify the system we need to prior the knowledge of controller.
3. Another problem is that if the plant model is linear then it appears in non linear condition.
4. For real time system we can predict the future value and increase the system efficiency.

Real time identification for closed loop is calculated by identification method. We can identify the system with any method it is not necessary to choose only a specific method. By real time identification we can improve the performance of the system. Real time system identification for any system are to define the plant and for determine this we need to know the all parameter like input and output of the system to determine the plant [4]. Closed loop system identification are used because if the plant unstable we can't identify the system. Using the Markov chain estimation we can identify the system. There are two steps which can use for closed loop identification in Markov chain [4].

In first stage it determines the closed loop Markov parameter by the observer and second stage it determines the open loop parameter by the closed loop Markov parameter all two stage define the relation between the closed loop Markov parameter and Markov parameter. Identification method developed based on the perception of closed loop system. For two stage method when we applying error prediction model which can be used to analyzed in respect of the form an adaptive correlated noise or signal transfer function. This is used to determine the input output transfer function of the system which used to generate the input of the opposite case of the system [6]. Estimate by two stage method are less precise but it satisfies the stability condition. For noise adaptive correlation direct approach and precision estimate and calculated could be advantage over the joint input output approach [5]. For identification of

the system noise model are having important because of some method we need good noise model for identification of the system. We know that for the direct and indirect approaches we need good noise parameter model [3].

LITERATURE REVIEW

Urban forsell, Lennart ljung(1999) illustrated the approach of the system identification for the system and define the problem between the input data and unwanted signal. They define that if the feedback controller is not zero than the data which gave the signal and the unwanted signal are correlated with each other. There are some approaches to closed loop identification. They are used for identification method and this are the main approach for identify the systems. The approaches are the direct, indirect and joint input and output. All this approach are having different algorithm to identify the system. By using all this approach we identify the closed loop system. For direct approach was not used after the system is unstable. Idea behind the indirect approach is to be that if the controller having the more data inputs are known we can use indirect identification. This method is used for non linear feedback.

Alireza karimi, Ioan dore(1997) in this comparison of the closed loop identification method. They described the comparison in terms of bias supply. Direct method, indirect method and joint input output method are used to the analyzed and estimate the system. Direct method and two stage method are used for the system identification. By using direct method, we can identify the system by input and output data of closed loop system. Direct method it considers single input single output system and second method is two stage identification where the system having two stage. There are two stages in this method first method are that transfer function of execution nit and the plant is defined in open loop. Two stage method identify determine the closed loop system as open loop system. Knowledge of controller is not required if we have measurements of both the reference signals.

Minh phan, Richard longman(1994), they exemplify the system identification with known output feedback. Main problem in identification of open loop system when it operating under closed loop system. The identification of a system having a linear output feedback controller is formulated. This is the simple case on which the several extensions are made. If the open loop system has a direct transmission than the mathematical term to some extent and this case are treated as next. For this identification method developed for define a concept of an observer for the closed loop system. For this first problem is to define problem of identification open loop system with linear feedback controller. In this Markov parameters are identified and open loop system are recovered from the identification closed loop parameters and define the relation between the Markov estimation and closed loop Markov parameters.

Lianming sun, Yasuhiro miyake(2002), they define the closed loop unstable system and an application of closed loop system using direct method. This method approach are used for inter sampling scheme in which it takes faster output than the input of the system. For magnetic suspension are always stabilized by feedback control. Open loop identification there some serious problem which are considered in closed loop identification. One problem bias which is caused by the correlation of control input and output disturbance in closed loop system. It estimates the closed loop algorithm which is used for estimate the problem and identifies the system. Obtain the single input and multiple output system for identification of the system. For any unstable system like magnetic suspension we can use closed loop system by feedback control and identify the system and helpful for all unstable plant.

Paul van dan hof, Ruud schrama(1995), there are some issues in identification process for closed loop system they define the identification and control issue for closed loop system. For identification of dynamic system has motivated and supported by the ability to use result model as for model based propose. In system identification importance has long been aspects of consistency and related to word the reconstruction of the plant that measures the data. There are some challenges for identification of the system and control designs are closely to each other. Identification methods transport a model of plant with unknown dynamics. Some methods deliver also an uncertainty. A nominal model is just an approximation of the plant. Based on this model a control has been designed. There are two branches to identifies the system it concludes that first we design the control check its performance and after this performance the system will quantification the error in the system after that identify the system which is suitable for the system and after this process easily perform the action to the plant.

Rimantas Pupeikis (2002) , this paper is identification of the close loop system identification using closed loop. In this paper it also uses three main approach: direct approach, indirect approach and joint input-output approach and it is also used two stage method which is helpful for system identification. In this paper a two-stage method, applying the prediction error model, will be examined in respect of the form of an adaptive correlated noise transfer function. The additive correlated noise in explanations to be processed strongly influences the quality of the closed-loop identification. Therefore, the simplicity of the direct approach and the accuracy of estimates calculated by it could be the main advantage in comparison with the joint input-output approach if not for one problem. An increase of strength of additive noise, the estimates of the parameter in the denominator of the open-loop system transfer

function take the standards outside of the stability area of parameters. On the other hand, the estimates obtained by the two-stage method are less accurate but they satisfy stability conditions even under intensive noise.

2.Methods for Closed Loop Identification

Mainly, there are four methods for closed loop identification. For most of the systems, this method works. There are describe as following,

1. Direct Method: In this method we take data of input and output are taken from the plant which operating in closed loop system are identify by direct method. Direct method are uses classical open loop algorithm for identify the system. Direct method is simple method for identification of the system. This approach is ignoring the feedback and identifies the open loop system by using measurement of the input and output of the system. Direct method generates the data from the input and output [2]. We determine the closed loop data with the open loop data. Main disadvantage of direct method is that the signal to noise ratio(SNR) is to be high that's why we need a good quality noise model [1]. Suppose we have good model than the result of this are biased. In this method we apply prediction error method directly to the data. The direct method is not directly used when the system is unstable. Direct method is avoids the possible feedback. The main advantage of this method that we there is no need of the algorithm or software to use this direct method. For direct method we only collect data from input and output and applied any prediction method which can identify the system [5].

2. Indirect Method: In this method we can identify the system by the measurement of the reference and output of the system. Determine the open loop parameter form the closed loop model. This approach identifies the transfer function of closed loop system and determines the parameters of open loop system using linear controller. There are some advantages of this method is that we not required any noise model [2]. Indirect method having some disadvantage that we need to the prior knowledge of the controller which is used for identification and another is that it gives some error to the system. Indirect method is differed from the direct method because for this method we need to whole knowledge of controller that we can use for the system we collect the data from the input and output and define the system by the knowledge of controller.

3. Joint input output method: In this method the data are joints separately as the output of the system. In this approach input and output jointly as the output from a system driven by some extra output or set point signal and noise. For joint input output approach we not need to require the prior knowledge of the system and no need to require the noise model. But this method is need more hardware part and software part for identification [3]. Sometime we need the sensor for operate the system when the system is unstable. For joint input output approach we can identify the system by using the transfer function of the system and transfer function data are defined by the input and output of the system then we can define the system.

4. Two Stage Method: There are two stages in this method first method are that transfer function of execution nit and the plant is defined in open loop. Two stage method identify determine the closed loop system as open loop system [4]. Knowledge of controller is not requires if we have measurements of both the reference signals. For two stage method that we can observe the both the signal and no need of the noise model for this method but it require high signal to noise ratio (SNR). For two stage method it is difficult to identify the system because of we need high in the system.

After that there is another stage for this method, second method are that execution input are filtered by transfer function which is used as a variable generator a noiseless input for identifying the plant.

4.1. Process for System Identification

In figure (2) is the algorithm for system identification process which are useful for understanding the whole process. According to this algorithm for any plant we collect experiment from experimental design and after collect data we choose an appropriate model structure which is helpful for system and perform more than other. After choosing model employ a criterion which is fit for the system after that estimate model parameter. After taking all parameter access the model and check the parameters of the system and compare the data with known response, errors in parameters estimation. After all this process system check the process if it satisfies then we use the system if it not satisfied then process go back previous step and check the parameter and perform the process again until the system not in use, Using this algorithm we can easily identify the system.

In fig (2), algorithm used for any methods which are used for system identification. We do estimation for the system using parameter estimation modeling. For parameter estimation modeling having some stage so that first we define the problem then model formulation then estimate the parameter after doing estimation then we do model validation. After the entire task we identify the system [1]. So that for identify the system we need to define the problem, problem could be an industry work so that we define the problem after this we do model formulation. In model

formulation we choose input data, for theoretical modeling it is very important and the important fact is to keep in mind that information not contained in data not appear in the model. After model formulation next step is parameter estimation, in parameter estimation we do estimation the unknown parameters which is helpful for model [4].

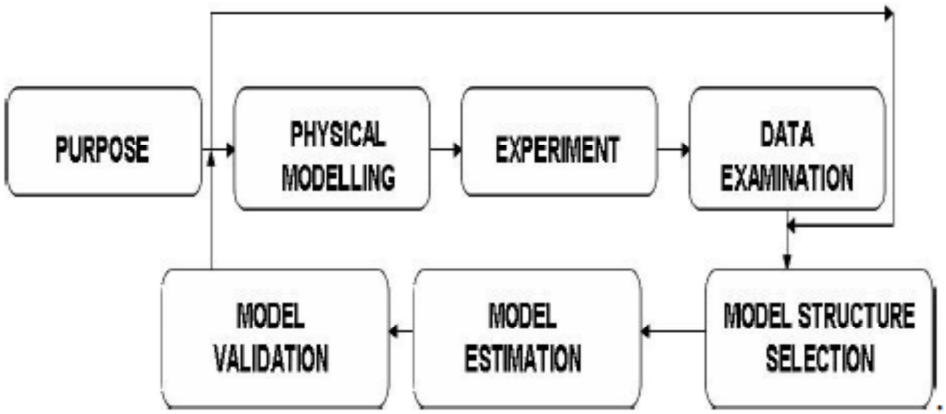

Fig 2 System process algorithm

Parameter estimation can be done in both frequency domain and time domain. Estimation can do for theoretical modeling and practical modeling for unknown parameters. After estimation the parameter estimation the most important task is that to validation of the model and if the model is satisfied then we can use the model for identification [7]. Model validation is that we can check all the parameters and modeling of the system. Suppose some parameter is not satisfied for the system then we need to do all process again till the model is not satisfied for the system. Parameter estimation modeling is used to define the model parameters [5].

CONCLUSION

In this paper, methods of closed loop identifications are summarized. The closed loop identification is useful for many case as discussion in this work. A plant model is very useful for analysis of the system, design of controller , fault identification and etc. In most of the method, they use open loop identification approach. They synthesis in different way depending upon the method. Indirect method, assume that you know structure of the controller. For online identification, this closed loop identification is very important. For different industry, it is useful for development of plant model.

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