



Identification Analysis of Control System Using Programming Language Python

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Abstract

The paper describes the matrix parameters of continuous control system by a regression approach: state -space equation in the continuous or discrete forms. The example of the system regression analysis is discussed according to the example of residual moisture stabilization system of material in a drying apparatus, the structural scheme is given. The coefficients of state space equation are represented by matrix and numeric value. The obtained results are graphically illustrated. The modern and widespread programming language Python and Python Control System Library are used at all stages of research.

Keywords: Control system, identification, regression analysis, verification, state-space.

1. Introduction

Today, the methods of Regression Analysis have been successfully used to process the experimental data in Biology, Economics, Automation and other fields. In regression analysis all available resources should be used completely and efficiently, especially if we are dealing with the accumulation and processing of information. The development and perfection of the identification method are required for increasing the accuracy and reliability of dynamic objects in many fields of science and technology. Today, the most required methods of evaluation of experimental data provide high rates of efficiency, reliability, consumed energy savings and memory volume. Solving the problems of processing numerical algorithm for signals and parameters evaluation in linear dynamic object will solve all practical tasks. The purpose of the work is to evaluate the matrix parameters of control system with regression approach by using the programming language Python and integrated Python Control Systems Library

2. Theoretical Part

The state-space equation of continuous system has the form [1]:



$$\begin{cases} \dot{X}(t) = AX(t) + BU(t) \\ Y(t) = CX(t) + DU(t) \end{cases} \quad (1)$$

Where $X(t)$ - is a state vector n size; $U(t)$ - is a control vector size r ; $Y(t)$ - is a system output vector size; A - $n \times n$ state matrix size; BC and $D=0$ input, output and zero (null) matrix. In our case the task is to determine the matrix real numbers A, B, C, D of system parameters. (1) should be represented by the discrete forms for regression analysis of the system:

$$\begin{cases} X[(k + 1)T] = A_d X(kT) + B_d U(kT) \\ Y(kT) = CX(kT) + DU(kT) \end{cases} \quad (2)$$

Where T – is a by quantization step by time; K - whole number; C, D –is a matrix discrete system of the same dimension, that is the initial continuous system.

A_d and B_d matrices have the following form[2]:

$$A_d = e^{AT}, \quad (3)$$

$$B_d = \int_0^T e^{AT} BT. \quad (4)$$

3. Practical Part

We should only use input impact and the value of state vector to evaluate the matrix parameters. Let's consider A and B matrix regression analysis of control system for the open system of the residual moisture stabilization of material in a drying apparatus, that consists of three inertial parts with the following parameters: $K_1 = 0,2, T_1 = 16$ s; $K_2 = 0,2, T_2 = 6,6$ s; $K_3 = 0,15, T_3 = 2$ s[3]. Obtain the input impact on the system in the form of $u(t) = e^{-0,6t} \cos(2t)$. Obtain the system initial condition as a zero in the state variable The open system of the residual moisture stabilization of the drying material in the drill drying apparatus has the following form:

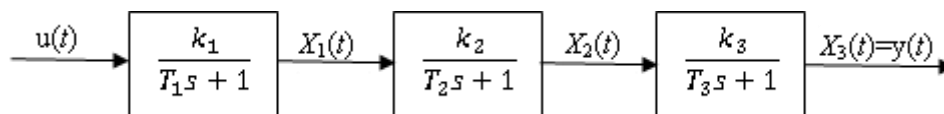


Fig. 1. Open System of residual moisture stabilization

The transfer function of the system is determined for zero initial conditions; therefore, s complex variable may be formally changed by the product. So finally, the connection between the input and output values of the system may be represented by the following differential equation:

$$\begin{cases} \dot{x}_1(t) = -\frac{1}{T_1} x_1(t) + \frac{k_1}{T_1} u(t); \\ \dot{x}_2(t) = \frac{k_2}{T_1} x_1(t) - \frac{1}{T_2} x_2(t); \end{cases} \quad (5)$$

$$\dot{x}_3(t) = \frac{k_3}{T_3} x_2(t) - \frac{1}{T_3} x_3(t).$$

System may be represented by a matrix form and the matrix of control system will have the following form:

$$A = \begin{bmatrix} -\frac{1}{T_1} & 0 & 0 \\ \frac{k_2}{T_2} & -\frac{1}{T_2} & 0 \\ 0 & \frac{k_3}{T_3} & -\frac{1}{T_3} \end{bmatrix}, B = \begin{bmatrix} \frac{k_1}{T_1} \\ 0 \\ 0 \end{bmatrix}, C = [0, 0, 1], D = 0, \quad (6)$$

Taking into account the numeric values of the parameters of the system inertial parts, we will obtain: The transformation of discrete system into matrix continuous system is implemented by specialized functions: `ss(Create a state space system)`, `d2c(discrete to continuous conversion)`, `ssdata(Return state space data objects for a system)`[4].

The results of the program implementation have the following form:

```
A =
-0.0625    0    0
 0.0303 -0.1515    0
 0    0.0750 -0.5000
```

```
B =
 0.0125
 0
 0
```

```
C =
 0  0  1
```

```
D =
 0
```

```
Ad =
 0.9994    0    0
 0.0003  0.9985    0
 0.0000  0.0007  0.9950
```

```
Bd =
 1.0e-003 *
 0.1250
 -0.0000
 0.0000
```

```
Adr =
 0.9994 -0.0000  0.0000
 0.0003  0.9985  0.0000
 0.0000  0.0007  0.9950
```

```
Bdr =
 1.0e-003 *
 0.1250
 -0.0000
```

```

0.0000
Areg =
-0.0625 -0.0000 0.0000
0.0303 -0.1515 0.0000
0.0000 0.0750 -0.5000
Breg =
0.0125
-0.0000
0.0000
    
```

Whose transition characteristics are shown in Fig.2. The analysis of the obtained results shows that the evaluation of the matrix system is quite accurate.

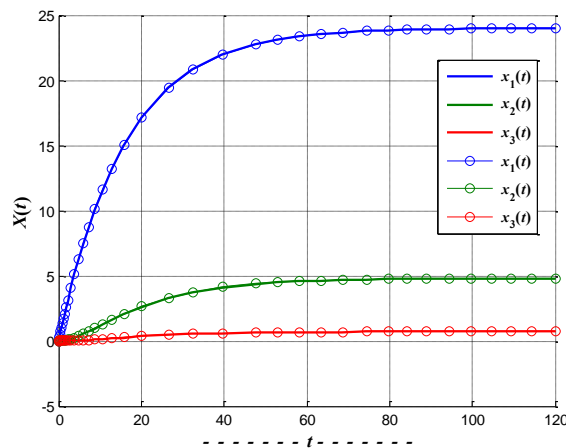


Fig. 2. Transfer functions of state variables

On the other hand, let's do the regression evaluation of the matrix output parameters of the same system. Matrices of control systems are determined by (6) the images. We have made the regression identification of C output matrix based on the equation $Y(t) = CX(t)$. The results of the program implementation are represented by the following way:

```

C =
0 0 1
Cdr =
0.0000 0.0007 0.9950
Creg =
0.0000 0.0007 0.9950
    
```

The diagram of the system output process in verification is shown in Fig. (3).

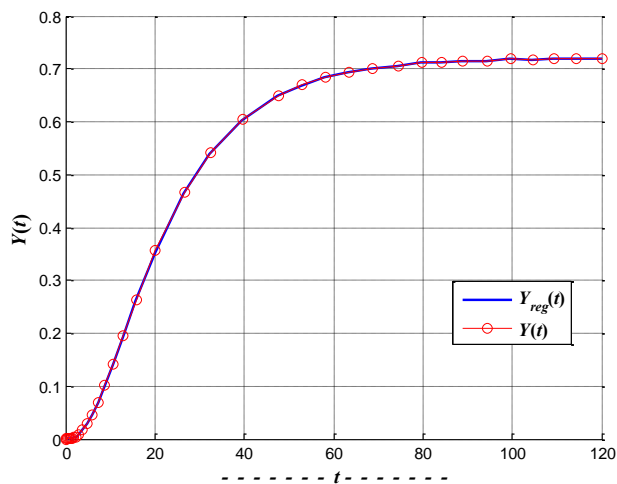


Fig. 3. Transition process on the system output

4. Conclusions

As a result of the survey, the regression evaluation of the matrix of continuous linear system is sufficiently accurate. Such approach of the system regression analysis may be successfully used in various fields that will give us the ability to use all available resources in full and efficient manner.

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