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DYNAMIC AND DISCRETE EVENTS MODELING.

Annotation: *This article provides an overview of dynamic and discrete event modeling, two key approaches to systems analysis. The article discusses the definition and application of these approaches in various fields such as industry, transportation, medicine and finance. The technologies used to implement modeling and the prospects for the development of this area are also discussed.*

Keywords: *Modeling, dynamic events, discrete events, systems, analysis, application, technology, artificial intelligence, Internet of things, distributed modeling.*

Any management system consists of a set of interconnected elements. In order to study and control the physical properties of such a system, it is necessary to express it mathematically. The system is in motion during operation, and this motion characterizes its state. The state variables of the system are represented by interrelated equations. In this case, the state variables of the system can be different. For example: electrical quantities (current, voltage, power), mechanical quantities (displacement, deflection, sliding) and other quantities (temperature, level, time....) [1].

It is convenient to represent the system with one generalized parameter, where the system and its elements are called **signal converters .**

Dynamic system systems that are in motion and can change their state over time. Dynamic automatic control systems can generally consist of the following devices:

1. Assignment device. 3. Implementation device.
2. Manager device . 4. Management object .

Dynamic to systems example by doing manage Systematic projectiles, itself fly devices, chemical, thermodynamic and technological processes show can This systems analysis by doing common without automatic manage in systems dynamic processes mathematician in terms of to express trying we will see [2]. Of this for reverse connected the following dynamic to the system effect doer main indicators set we get:

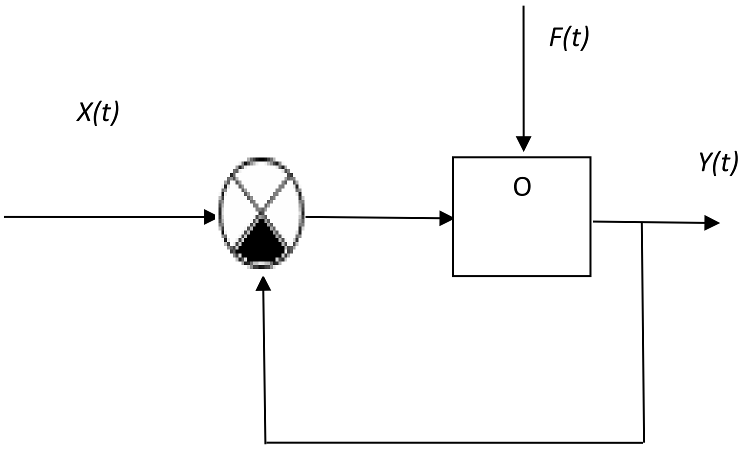


Figure 1 Management system structural scheme

here : _ _ _

$X(t) =$ ¿ ¿- assignments vector ; (1)

$Y(t)=\{y_1(t), y_2(t), \ldots, y_n(t)\}$- managed indicators vector ;

$F(t)=\{f_1(t), f_2(t), \ldots, f_n(t)\}$- external impact _ _ vector .

This dynamic the system common without the following dynamic system with to express can:

$$F_1\left(y, \frac{dy}{dt}, \frac{d^2y}{dt^2}, \ldots, \frac{d^ny}{dt^n}\right) = F_2\left(x, \frac{dx}{dt}, \frac{d^2x}{dt^2}, \ldots, \frac{d^mx}{dt^m}, f, \frac{df}{dt}, \frac{d^2f}{dt^2}, \ldots, \frac{d^yf}{dt^y}\right) \quad (2)$$

differen s ial equation dynamic systems expressive mathematician expression being his _ apparently looking dynamic systems one how many type to be can _ For example : differential in Eq $F1$, $F2$ functions linear functions if , then this linear differential equations with expressible systems **linear dynamic systems** is called If differen s ial in Eq F_1, F_2 functions non-linear to the character to e if, then differen s ial equation non-linear differen s ial equation with him expressible systems **non-linear dynamic systems** is called

Differen s ial in Eq x, y, f of from derivatives except their private Derivatives also participate can _ Such private derivative differen s ial equations with expressible systems **special dynamic systems** is called If the system expressive the mathematical model is finite different equations in the form of if, then such systems **impulsive or discrete dynamic systems** is called common without linear dynamic of systems mathematician model the following high in order linear differential equation in the form of to write can:

$$a_0\frac{d^n y}{dt^n}+a_1\frac{d^{n-1}y}{dt^{n-1}}+\ldots+a_{n-1}\frac{dy}{dt}+a_{n-1}\frac{dy}{dt}+a_n y=b_0\frac{d^m k}{dt^m}+b_1\frac{d^{m-1}}{dt^{m-1}}+\ldots+b_{m-1}\frac{dx}{dt}+$$
$$+b_m x+c_0\frac{d^y f}{dt^y}+c_1\frac{d^{y-1}f}{dt^{y-1}}+\ldots+c_{y-1}\frac{df}{dt}+c_y f \qquad (3)$$

This to Eq the following designations we enter :

$$p=\frac{d}{dt},\ \ p^2=\frac{d^2}{dt^2},\ \ \ldots,\ \ p^n=\frac{d^n}{dt^n} \quad (4)$$

In that case equation the following to look to e will be :

$$(a_0 p^n+a_1 p^{n-1}+\ldots+a_{n-1}p+a_n)\cdot y=(b_0 p^m+b_1 p^{m-1}+\ldots+b_{m-1}p+b_m)x+$$
$$+(c_0 p^y+c_1 p^{y-1}+\ldots+c_{y-1}p+c_y)\cdot f \qquad (5)$$

This equation for the following designations we enter :

$$a_0 p^n+a_1 p^{n-1}+\ldots+a_{n-1}p+a_n=A(p) \quad (6)$$

$$b_0 p^m+b_1 p^{m-1}+\ldots+b_{m-1}p+b_m=B(p)$$

$$c_0 p^y+c_1 p^{y-1}+\ldots+c_{y-1}p+c_y=C(p)$$

This expression P to relatively a lot that if we get equation the following to look will come :

$$A(p)\cdot Y(t)=B(p)\cdot x(t)+C(p)\cdot f(t) \quad (7)$$

equation is an expression of linear dynamic equations in the form of Laplace operator [3,4].

Another feature of linear dynamic systems is that the principle of superposition is appropriate for them. The meaning of this principle is that if the input of a linear dynamic system receives a signal formed from a linear combination (addition, subtraction) of several signals, the system reaction, that is, the output signal, $Y(t)$ gives the signals separately to the system input , the sum or difference of the resulting reaction must be equal to each other [5].

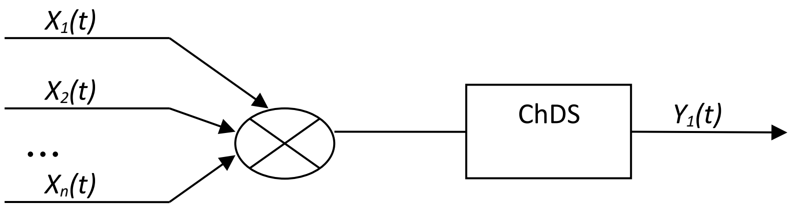


Figure 2. Linear dynamic systems.

Systems with the principle of superposition are called **linear dynamic systems** . Systems where the principle of superposition is not appropriate **non-linear dynamic systems** is called From this except automatic manage systems in theory non-stationary systems are also available they are _ _ the following differen s ial equations in the form of is represented by:

$$a_0(t)\frac{d^n y}{dt^n}+a_1(t)\frac{d^{n-1} y}{dt^{n-1}}+\ldots+a_n(t)y(x)=b_0(t)\frac{d^m x}{dt^m}+b_1(t)\frac{d^{m-1} x}{dt^{m-1}}+\ldots+b_m(t)x+$$
$$+c_0(t)\frac{d^y f}{dt^y}+c_1(t)\frac{d^{y-1} f}{dt^{y-1}}+\ldots+c_y(t)f \quad (8)$$

This from Eq visible _ is non- stationary of systems dynamic indicators equation coefficient e nts time during changed will go yes _

If the system in the composition never 1 signal if not time according to if it is a quantizing element , it is like this to systems **impulsive dynamic** are called **systems** . For example : Key . Non-linear dynamic systems in the composition never if not one is a nonlinear element , and their mathematician model non-linear differential equations in the form of is written [6]. For example : Relay .

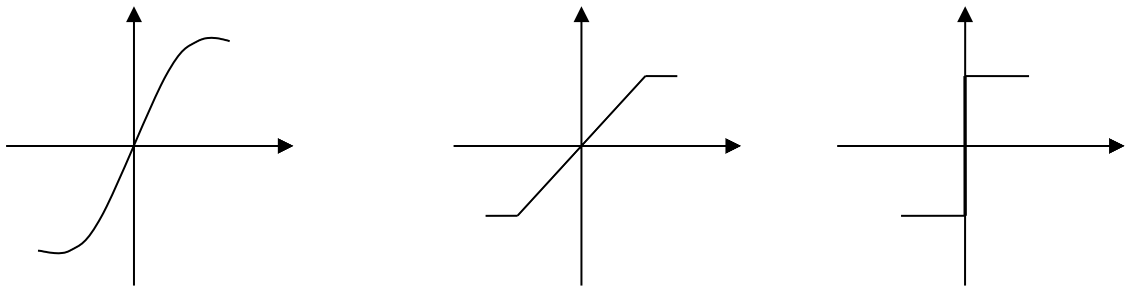


Figure 3 is pulsed dynamic systems

Static characteristics are algebraic equations through , dynamic characteristics by differential equations is expressed .

Suppose that the state of the system is written by differential equations.

$$F\left(\ddot{y}, \dot{y}, y, \dot{x}, x\right) + f = 0 \quad (9)$$

The static view of the equation is as follows.

$$F(0,0,y,0,x) + f = 0$$

In real systems, its static and dynamic characteristics are written by nonlinear equations. Solving nonlinear equations is more complicated [7,8].

Converting nonlinear equations into linear equations is called ***linearization*** .

Linearization is usually done relative to the equilibrium state. In this case, the deviation is very small. For this, the nonlinear equation is expanded into a Taylor series, and each variable is multiplied, that is:

$$x = \Delta x + x_0 \quad (10)$$

$$y = \Delta y + y_0$$

$$f = \Delta f + f_0$$

If we look at the expressions in relation to the deviation, the equation is written as follows:

$$F=(\Delta\ddot{y},\Delta\dot{y},\Delta y+y_0,\Delta\dot{x},\Delta x+x_0)+\Delta f+f_0 \quad (11)$$

we expand the equation into a Taylor series based on the equilibrium equation:

$$F(0,0,y_0,0,x_0)+\left(\frac{dF}{d\ddot{y}}\right)_0\Delta y+\left(\frac{dF}{d\dot{y}}\right)_0\Delta y+\left(\frac{dF}{dy}\right)_0\Delta y+\left(\frac{dF}{dx}\right)_0\Delta x+\ldots=0 \quad (12)$$

Then the equation will look like this:

$$a_0\Delta\ddot{y}+a_1\Delta\dot{y}+a_2\Delta y=b_1\Delta x$$

example:

RC Let the chain be given. The differential of the circuit given in Fig. 1 let the equation be formed.

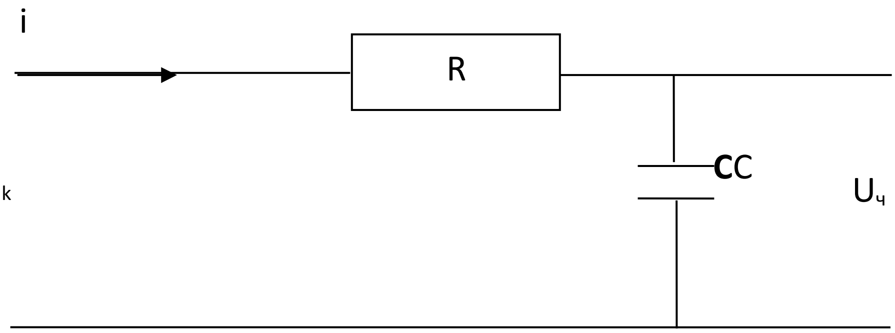


Figure 4 RC circuit diagram.

$$U_{ch}(t)=A\cdot U_k(t) \quad (13)$$

$$A=\frac{U_{ch}(t)}{U_k(t)}$$

$$U_k(t)=i(t)\cdot R+\frac{1}{c}\int_0^t i(t)\,dt$$

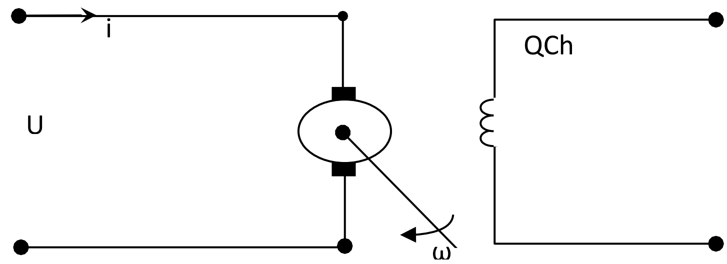
$$U_{ch}(t)=\frac{1}{c}\int_0^t i(t)\,dt$$

$$\frac{dU_{ch}(t)}{dt}=\frac{1}{c}i(t)$$

$$i(t)=c\cdot\frac{dU_{ch}(t)}{dt}$$

$$U_k(t)=R\cdot C\frac{dU_{ch}(t)}{dt}+U_{ch}(t) \qquad R\cdot C=T$$

$$T\cdot\frac{dU_{ch}(t)}{dt}+U_{ch}(t)=U_k(t)$$



Let's build the mathematical model of the DC motor shown in Figure 5.

5 - picture . DC motor.

$$J\frac{du\ell}{dt}=M_g-M_q \quad (14)$$

where ω is the engine speed, M_g is the engine torque, and M_q is the resistance torque.

In this case, the engine torque:

$$M_g=M_g(\omega,u)\ M_q=M_q(\omega,t); \quad (15)$$

In the equilibrium state, the engine torque $M_{g0}=M_{q0}$ is

$$u=u_0+\Delta u$$
$$\omega=\omega_0+\Delta\omega \quad (16)$$

Based on the above, we write the engine torque as follows [9,10]:

$$M_g=M_{g0}+\left(\frac{dM_g}{d\omega}\right)\Delta\omega+\left(\frac{dM_g}{du}\right)\Delta u \quad (17)$$

$$M_q=M_{qo}+\left(\frac{dM_q}{d\omega}\right)\Delta\omega_0+\Delta M_q$$

These expressions to Eq let's say the following equation harvest will be :

$$J\frac{d\omega}{dt}=M_g-M_q=J\frac{d\omega}{dt}=\left(\frac{dM_g}{d\omega}\right)\Delta\omega+\left(\frac{dM_g}{du}\right)\Delta u-\left(\frac{dM_q}{d\omega}\right)\Delta\omega-\Delta M_q \quad (18)$$

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