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Global practical control for a class of high-order inherently nonlinear systems

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Currently, one of the pressing problems of control theory is the automatic control of tracking systems. Tracking systems are widely used in automatic control of autopilots, control of missiles or unmanned aerial vehicles (UAVs) along a predetermined path, automatic temperature control in the chemical industry, automatic adjustment of the position of absorbing rods in nuclear reactors, control of robotic manipulators in production, etc. with this, it plays an important role in control theory. Currently, it is relevant to study the effective use of UAVs, such as quadrocopters or hexacopter, in agriculture or in the delivery of medical supplies to people in the disaster area. Full knowledge of control systems allows you to simulate many complex systems.

Nonlinear systems are an important branch of control theory. All physical systems found in nature are nonlinear. Linear systems are used to describe and control the system, provided that the system does not deviate from the nominal set of current states. Otherwise, the linear model is not considered effective and we will not get the desired results. In this case, nonlinear systems are used. This is because nonlinear controls can directly control large nonlinear systems. Even if the rank of the system is small enough, linearization is not always possible, because there are systems whose linear state is not controlled at any equilibrium point. For such systems, control theory should be used. There are many types of mathematical analysis tools in the theory of nonlinear control. Due to the lack of a universal mathematical method or tool for non-linear analysis, the research topic is relevant.

In the work, p-normal nonlinear systems belonging to the same class of nonlinear systems were studied control and tracking problems were studied. As a result of the study, the computer simulated the problems of stabilization of the states of p-normal nonlinear systems with dynamic feedback on the output, the problem of controlling the output of a p-normal nonlinear system, as well as the task of controlling a p-normal nonlinear system with a time delay.

Research Methods. Feedback method, Lyapunov systems control methods, recursive method, numerical method, uniform domination method, induction method, double compensator-regulator method, Lyapunov-Krasovsky method, Euler method, Runge-Kutta method.

Algorithm. An algorithm was developed and a computer model for finding control of real nonlinear systems that tracks a given reference signal.

```
if  (val1==1) && (val5==1)
  {    yr=sin(t).^3;
   runge_kutta(yp1, yp2, yp3, u, yr, delay, y0_initial, t0_tfinal);  }
else if (val2==1) && (val5==1)
  {    yr=cos(t).^3;
   runge_kutta(yp1, yp2, yp3, u, yr, delay, y0_initial,t0_tfinal);   }
else if (val3==1) && (val5==1)
  {    yr=sin(t./3)+sin(t)
   runge_kutta(yp1, yp2, yp3, u, yr, delay, y0_initial, t0_tfinal);  }
else if (val4==1) && (val5==1)
  {    yr=cos(t).^2
  runge_kutta(yp1, yp2, yp3, u, yr, delay, y0_initial, t0_tfinal);   }
```

Result.

Table 1 - Error table between the first equation state of a nonlinear system with a time delay parameter and the reference signals

L	y_r	x_1-y_r	y_r	x_1-y_r
100		1,182960		1,380631
300		0,800768		1,135224
500	*sin(t/3)+sin(t)*	0,555128	$(cos(t))^2$	0,819673
700		0,364994		0,376236
900		0,157663		0,090964
1100		0,031358		0,028719

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