UDC 51-77

The Research of Loss Stability of Level of Psychical Reaction of a Human with the Power of Informational Influence on Him

A. N. Kudinov, E. V. Chusova

Department of Mathematical Modelling
Tver State University
33, Zhelyabova str., Tver, Russia, 170100

In recent years significantly increased the negative information and psychological impact on the individual and mass consciousness. Therefore, strongly expressed of emergence of aggression, anxiety, despair, hopelessness, depression, a criminal manifestations and mental illness. The research of stability of level of psychical reaction with personal characteristics of a human and with the power of informational influence on him is presented in the article. The adjoin method offered by Kudinov A.N. was applied to research of the loss of stability. The main advantage of the adjoin method is that for use to the problems of dynamic stability studies in various fields of science, technology, biology, medicine and psychology, if their equations can be reduced to the equations of second order, don't demand the introduction of Lyapunov functions. The adjoin method permits to find the equilibrium positions and to check the stability of nonperturbed state. Also the research of stability by Lyapunov's method on first approximation is conducted, as a result the stability conditions of psychical reaction with personal characteristics of a human and with the power of informational influence on him are presented.

Key words and phrases: the stability, psychical reaction, informational influence, the adjoin method, Lyapunov's method on first approximation.

1. Introduction

In recent years significantly increased the negative information and psychological impact on the individual and mass consciousness. Strongly expressed of emergence of social tensions, aggression, anxiety, despair, hopelessness, criminal manifestations and mental illness.

2. Mathematical Model

R. Kettel, and a little later G. Ayzenk showed of mathematical model describing the level of psychical reaction of a human in extreme situation

$$K = f(S, P),$$

where P — personal characteristics of a human, S — characteristics of extreme situation (informational influence), K — feedback [1].

Mechanical system of level of psychical reaction of a human on of informational influence has the form:

$$m\frac{\mathrm{d}^2Y}{\mathrm{d}t^2} + r\frac{\mathrm{d}Y}{\mathrm{d}t} + cY = X, \tag{1}$$

where m — inertial mass of the system, r — coefficient of viscous friction, c — stiffness.

If some of the force X acts on the mechanical system, then the system is set in motion (begins to move) [2]. Also there are different losses, and the amount of movement Y is connected with the value of X the differential equation of dynamics. If the force X is force of information influence (S), and Y is level of psychical reaction of the person (K), then m, r and c are characteristics of the person P (rigidnost, frustrirovannost and aggression). Thus, the equation of dynamics of mechanical system describes process, similar to mental reaction of the person.

Received 30$^{\text{th}}$ December, 2013.

The equation of mechanical system describing the model of psychical reaction has the form [1]:

$$R\frac{\mathrm{d}^2Y}{\mathrm{d}t^2} + Z\frac{\mathrm{d}Y}{\mathrm{d}t} + \frac{A}{Q^2}Y = X, \tag{2}$$

where R — rigidity, Z — coefficient depending on the frustration, A — aggressive, Q — time parameter, X — power of informational influence.

Since mental reaction is oscillatory process, then the dynamic equation has the form

$$T^2\frac{\mathrm{d}^2Y}{\mathrm{d}t^2} + 2\zeta T\frac{\mathrm{d}Y}{\mathrm{d}t} + Y = kX, \tag{3}$$

where T — time constant , ζ — damping coefficient, k — gain.

Divide both sides of the equation (3) by k, we get

$$\frac{T^2}{k}\frac{\mathrm{d}^2Y}{\mathrm{d}t^2} + 2\zeta\frac{T}{k}\frac{\mathrm{d}Y}{\mathrm{d}t} + \frac{1}{k}Y = X. \tag{4}$$

The attenuation constant has the form $\zeta = \dfrac{F}{F_0}$.

Comparing the systems (2) and (4) clear, that $R = \dfrac{T^2}{k}$, $\dfrac{A}{Q^2} = \dfrac{1}{k}$, and coefficient $Z = 2\dfrac{F}{F_0}\dfrac{T}{k}$. Since $k = \dfrac{Q^2}{A}$, $T = \sqrt{R\dfrac{Q^2}{A}}$, then $Z = 2\dfrac{F}{F_0}\dfrac{\sqrt{RA}}{Q}$.

3. The Adjoin Method

Further we consider the differential equation (2) has the form:

$$\frac{\mathrm{d}^2Y}{\mathrm{d}t^2} + \frac{Z}{R}\frac{\mathrm{d}Y}{\mathrm{d}t} + \frac{A}{RQ^2}Y = 0.$$

Further equation we reduce to the system

$$\begin{cases} \dot{y}(t) = x(t), \\ \dot{x}(t) = \ddot{y}(t) = -\dfrac{Z}{R}x(t) - \dfrac{A}{RQ^2}y(t). \end{cases} \tag{5}$$

We research of stability of system (5) on the base of the adjoin method [3].

Then we write Hamiltonian:

$$H(p_1, p_2, x(t), y(t)) = p_1(t)x(t) + p_2(t)\left(-\frac{Z}{R}x(t) - \frac{A}{RQ^2}y(t)\right),$$

and compute the conjugate system that is linear relatively unknown functions $p_1(t)$ and $p_2(t)$

$$\begin{cases} \dot{p_1}(t) = p_2(t)\dfrac{A}{RQ^2}, \\ \dot{p_2}(t) = -p_1(t) + \dfrac{Z}{R}p_2(t). \end{cases} \tag{6}$$

Finding Jacobians for system (5)

$$J(x,y) = \begin{vmatrix} 0 & 1 \\ -\dfrac{A}{RQ^2} & -\dfrac{Z}{R} \end{vmatrix} = \frac{A}{RQ^2} \neq 0.$$

Further calculate Jacobian for system (6)

$$J(p_1(t), p_2(t)) = \begin{vmatrix} 0 & \dfrac{A}{RQ^2} \\ -1 & \dfrac{Z}{R} \end{vmatrix} = \frac{A}{RQ^2} \neq 0.$$

Accordingly for the main system and conjugate system, the Jacobians are nonzero, position of equilibrium exist at $\dfrac{A}{RQ^2} > 0$.

Let us write the linear equation of second order for the conjugate function $p_2(t)$. Since $\dot{p_2}(t) = -p_1(t) + \dfrac{Z}{R} p_2(t)$, $\dot{p_1}(t) = p_2(t)\dfrac{A}{RQ^2}$, then substituting we get

$$\ddot{p_2}(t) = \frac{Z}{R}\dot{p_2}(t) - \frac{A}{RQ^2} p_2(t), \quad \text{or} \quad \ddot{p_2}(t) - \frac{Z}{R}\dot{p_2}(t) + \frac{A}{RQ^2} p_2(t) = 0.$$

From the equations we can immediately see that the stability criterion of Hurwitz for the conjugate system is fulfilled, if $\dfrac{Z}{R} < 0$, $\dfrac{A}{RQ^2} > 0$, at any moment.

4. Lyapunov's Method on First Approximation

Also we have researched the stability of the system of differential equations (5) by Lyapunov's method on first approximation. For this purpose the matrix of coefficients has been written:

$$A = \begin{pmatrix} 0 & 1 \\ -\dfrac{A}{RQ^2} & -\dfrac{Z}{R} \end{pmatrix}.$$

The characteristic equation has form: $\det(A - kE) = 0$, where A is the matrix of coefficients of the system, E is the identity matrix.

$$\begin{pmatrix} 0 & 1 \\ -\dfrac{A}{RQ^2} & -\dfrac{Z}{R} \end{pmatrix} - k \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} = 0,$$

$$\det(A - kE) = \begin{vmatrix} -k & 1 \\ -\dfrac{A}{RQ^2} & -\dfrac{Z}{R} - k \end{vmatrix} = k^2 + \frac{Z}{R}k + \frac{A}{RQ^2} = 0. \qquad (7)$$

Solving the equations, we obtain that eigenvalues are equal:

$$k = -\frac{Z}{2R} \pm \sqrt{\left(\frac{Z}{2R}\right)^2 - \frac{A}{RQ^2}}.$$

Nonperturbed motion of the initial non-linear system is stable in usual sense, as (by stability criterion of Hurwitz) and (by condition $Z = 2(F/F_0)(\sqrt{RA}/Q)$).

5. Conclusion

Thus, we have made the research from a position of dynamic criterion. The main advantage of the adjoin method is that for use to the problems of dynamic stability studies in various fields of science, technology and medicine, if their equations can be reduced to the equations of second order, don't demand the introduction of Lyapunov functions.

References

1. *Либерман Я. Л., Метельков В. П.* Математическая модель уровня психической реакции человека и её исследование // Успехи современного естествознания. — 2004. — № 11. — С. 10–14. [Liberman J. L., Metelkov V. P. Mathematical Model of the Psychical Human Reaction Level and its Research // Advances in Current Natural Sciences. — 2004. — No 11. — Pp. 10–14. — (in russian).]
2. *Куффиньяль Л.* Кибернетика — искусство управления // Кибернетика ожидаемая и кибернетика неожиданная. — 1968. — С. 122–142. [Kuffinyal L. Cybernetics: art of management // Cybernetics Expected and Cybernetics Unexpected. — 1968. — Pp. 122–142. — (in russian).]
3. *Кудинов А. Н., Катулев А. Н., Кузнецов А. Ю.* Исследование устойчивости автономных нелинейных динамических систем // Материалы XVI Международного симпозиума «Динамические и технологические проблемы механики конструкций и сплошных сред» им. А. Г. Горшкова. — 2010. — С. 110–112. [Kudinov A. N., Katulev A. N., Kuznecov A. J. The Research of Stability of Independent Non-Linear Dynamic Systems // Materials of XVI International symposium "Dynamic and Technological Problems of Mechanic Constructions and Continuums" in the name of A. G. Gorshkov. — 2010. — Pp. 110–112. — (in russian).]

УДК 51-77

Исследование процесса потери устойчивости уровня психической реакции человека при информационном воздействии на него

А. Н. Кудинов, Е. В. Чусова

Кафедра математического моделирования
Тверской государственный университет
ул. Желябова, д. 33, г. Тверь, Россия, 170100

Актуальной проблемой в последние годы является увеличенный поток отрицательной информации и психологическое воздействие на людей и их сознание, в результате чего у людей начинают проявляться приступы агрессии, беспокойства, отчаяния, безнадёжности, депрессии, преступные проявления и психические заболевания. В статье представлено исследование устойчивости уровня психической реакции с личностными характеристиками человека и с силой информационного воздействия на него. Исследование проводилось на основе метода сопряжённых уравнений, предложенного Кудиновым А. Н. Данный метод даёт возможность его применения к задачам исследования динамической устойчивости в самых разных областях науки, техники, биологии, медицины и психологии, уравнения которых сводятся к уравнению второго порядка, при этом для исследования процесса потери устойчивости нет необходимости построения функции Ляпунова. Метод сопряжённых уравнений позволяет найти положения равновесия, проверить будет ли иметь место устойчивость невозмущённого состояния. Также проведено исследование на основе метода Ляпунова по первому приближению, в результате исследования представлены условия устойчивости уровня психической реакции с личностными характеристиками человека и с силой информационного воздействия на него.

Ключевые слова: устойчивость, психическая реакция, информационное воздействие, сопряжённый метод, метод Ляпунова по первому приближению.