

MUHANDISLIK & IQTISODIYOT

ijtimoiy-iqtisodiy, innovatsion texnik,
fan va ta'limga oid ilmiy-amaliy jurnal

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*ijtimoiy-iqtisodiy, innovatsion texnik,
fan va ta'limga oid ilmiy-amaliy jurnal*

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05.01.00 – Axborot texnologiyalari, boshqaruv va kompyuter grafikasi
05.01.01 – Muhandislik geometriyasi va kompyuter grafikasi. Audio va video texnologiyalari
05.01.02 – Tizimli tahlil, boshqaruv va axborotni qayta ishlash
05.01.03 – Informatikaning nazariy asoslari
05.01.04 – Hisoblash mashinalari, majmualari va kompyuter tarmoqlarining matematik va dasturiy ta'minoti
05.01.05 – Axborotlarni himoyalash usullari va tizimlari. Axborot xavfsizligi
05.01.06 – Hisoblash texnikasi va boshqaruv tizimlarining elementlari va qurilmalari
05.01.07 – Matematik modelashtirish
05.01.11 – Raqamli texnologiyalar va sun'iy intellekt
05.02.00 – Mashinasozlik va mashinashunoslik
05.02.08 – Yer usti majmualari va uchish apparatlari
05.03.02 – Metrologiya va metrologiya ta'minoti
05.04.01 – Telekommunikatsiya va kompyuter tizimlari, telekommunikatsiya tarmoqlari va qurilmalari. Axborotlarni taqsimlash
05.05.03 – Yorug'lik texnikasi. Maxsus yoritish texnologiyasi
05.05.05 – Issiqlik texnikasining nazariy asoslari
05.05.06 – Qayta tiklanadigan energiya turlari asosidagi energiya qurilmalari
05.06.01 – To'qimachilik va yengil sanoat ishlab chiqarishlari materialshunosligi
05.08.03 – Temir yo'l transportini ishlatish
05.09.01 – Qurilish konstruksiyalari, bino va inshootlar
05.09.04 – Suv ta'minoti. Kanalizatsiya. Suv havzalarini muhofazalovchi qurilish tizimlari
10.00.06 – Qiyosiy adabiyotshunoslik, chog'ishtirma tilshunoslik va tarjimashunoslik
10.00.04 – Yevropa, Amerika va Avstraliya xalqlari tili va adabiyoti

08.00.01 - Iqtisodiyot nazariyasi
08.00.02 - Makroiqtisodiyot
08.00.03 - Sanoat iqtisodiyoti
08.00.04 - Qishloq xo'jaligi iqtisodiyoti
08.00.05 - Xizmat ko'rsatish tarmoqlari iqtisodiyoti
08.00.06 - Ekonometrika va statistika
08.00.07 - Moliya, pul muomalasi va kredit
08.00.08 - Buxgalteriya hisobi, iqtisodiy tahlil va audit
08.00.09 - Jahon iqtisodiyoti
08.00.10 - Demografiya. Mehnat iqtisodiyoti
08.00.11 - Marketing
08.00.12 - Mintaqaviy iqtisodiyot
08.00.13 - Menejment
08.00.14 - Iqtisodiyotda axborot tizimlari va texnologiyalari
08.00.15 - Tadbirkorlik va kichik biznes iqtisodiyoti
08.00.16 - Raqamli iqtisodiyot va xalqaro raqamli integratsiya
08.00.17 - Turizm va mehmonxona faoliyati

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8. Toshkent kimyo-texnologiya universiteti
9. Jizzax politexnika instituti



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CONTROLLING EXECUTION MECHANISMS IN INTELLIGENT SYSTEMS USING NEURAL NETWORKS

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Abstract: In the current era of rapidly advancing technology (2025–2030), the effective management and automation of the manufacturing sector, along with the development of intelligent systems to ensure that products meet quality and quantity standards, have become urgent priorities. In this context, the application of neural networks for the rapid and convenient control of execution mechanisms used in the automatic regulation of technological parameters within intelligent systems is gaining increasing importance.

Keywords: production, engineering, neural networks, intelligent systems, technological processes, intelligent execution mechanisms, valves, motors, engines, pumps.

Annotatsiya: Hozirgi – texnika va texnologiyalar jadal rivojlanayotgan davrda – ishlab chiqarish sanoatini samarali boshqarish va avtomatlashtirish, mahsulotlarning sifat va miqdor ko'rsatkichlarini belgilangan standartlarga muvofiq ta'minlashda intellektual tizimlarni yaratish dolzarb masalaga aylanmoqda. Ayniqsa, intellektual tizimlarda texnologik parametrlarni avtomatik tarzda nazorat qiluvchi ijro mexanizmlarini qulay va tezkor boshqarishda neyron to'rlarni qo'llash zamonaviy yondashuv sifatida alohida e'tiborga loyiqdir.

Kalit so'zlar: ishlab chiqarish, muhandislik sohasi, neyron to'rlar, intellektual tizimlar, texnologik jarayonlar, intellektual ijro mexanizmlari, klapanlar, matorlar, dvigatellar, nasoslar.

Аннотация: В условиях стремительного развития техники и технологий эффективное управление и автоматизация производственной отрасли, обеспечение выпускаемой продукции в соответствии со стандартами качества и количества становятся приоритетными задачами. В этой связи особую актуальность приобретает использование нейронных сетей для создания интеллектуальных систем, а также для оперативного и удобного управления исполнительными механизмами, применяемыми для автоматического контроля технологических параметров.

Ключевые слова: производство, инженерия, нейронные сети, интеллектуальные системы, технологические процессы, интеллектуальные исполнительные механизмы, клапаны, моторы, двигатели, насосы

INTRODUCTION

Intelligent control systems (ICS) represent several key stages in the historical development of automation in industrial and technological processes. The earliest indications of automation can be traced back to the mid–19th century, when shaft rotation was regulated by controlling steam flow within a water boiler. At that time, production systems lacked basic automation components such as electrical and mechanical automatic devices – including relays, timers, and contactors. Instead, primary control tasks were carried out by mechanical systems operating based on predefined algorithms.

LITERATURE REVIEW ON THE TOPIC

In Uzbekistan, prominent scholars such as Academician N.R. Yusupbekov, Academician Kh.Z. Igamberdiev, Professor A.N. Yusupbekov, Professor Sh.M. Gulyamov, Professor Yu.Sh. Avazov, Professor M.A. Ismoilov, Professor F.T. Adilov, Professor Yu.G. Shepulin, and Associate Professor F.O. Kasimov have conducted extensive scientific research on the enhancement of executive elements, control systems, intelligent systems, and mathematical modeling of executive mechanisms.

In their research, significant emphasis was placed on the precision of executive mechanisms. Theoretical foundations for analytical calculations were developed using both dynamic and static data to assess control accuracy. These scientific works proposed and implemented information and software support, mathematical models, and structural schemes for efficient control and management of executive mechanisms within production enterprises.

RESEARCH METHODOLOGY

In this study, data were obtained through simulation modeling of executive mechanisms integrated with neural network algorithms. The performance of the control system was analyzed using comparative evaluation metrics, including response time, accuracy, and error rates. Experimental results were interpreted statistically to assess the effectiveness of neural networks in intelligent control applications.

ANALYSIS AND RESULTS

Traditionally, two main approaches are used to develop intelligent systems in technological processes and production. The first is the rule-based approach, which requires prior knowledge of all relevant laws and rules that define the domain of production and engineering. This is illustrated in the block diagram in Figure 1(a).

The second is the case-based approach, which requires a sufficient number of prior examples to configure an adaptive system with a desired level of confidence. Neural networks are a classical example of this approach, as shown in Figure 1(b). From the perspective of expert programming that underlies the rule-based approach, a neural network may be interpreted as a system that selects and applies a rule from among many pre-defined ones.

When designing a control base for execution mechanisms in technological processes, these rules can be integrated with others described previously. A hybrid approach is also widely used. It combines rule-based control with dynamic data retrieval from databases, result computation based on changing commands, and knowledge extraction from data via neural networks – particularly in tasks coordinated from a dispatch control monitor.

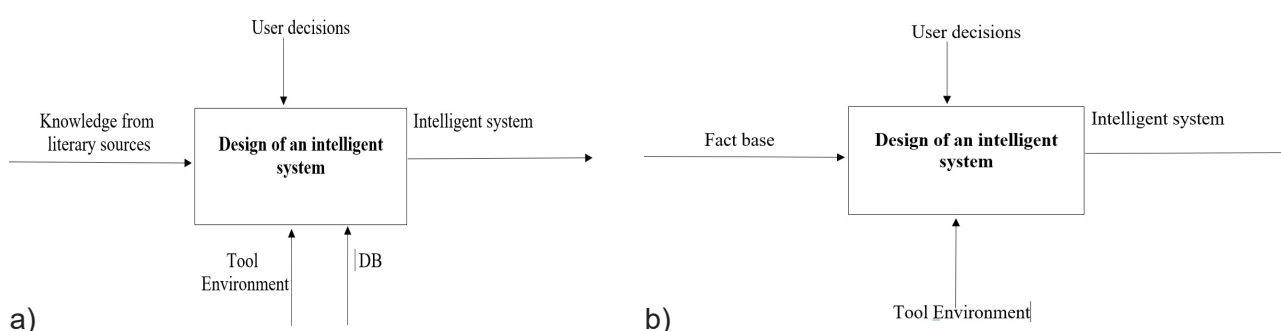


Figure 1: Functional connection scheme of an intelligent system.

Artificial neural networks (ANNs) are designed based on the organizational and operational principles of their biological analogs. These systems are employed to solve a wide spectrum of tasks, including decision-making, pattern recognition, forecasting, optimization, and control of complex, multi-object processes. The term “neural network” emerged in scientific literature in the mid–1950s, following foundational contributions by researchers such as W. McCulloch, D. Hebb, F. Rosenblatt, M. Minsky, and J. Hopfield.

Neural networks are particularly valuable in production process control, where optimal decision-making and adaptability are crucial. A classic example of a neural network model involves a function that restricts neuron activity to either 0 or 1, depending on the weighted sum of its inputs.



Input values are often binary, such as $x_i \in \{0, 1\}$. The threshold value (commonly referred to as the offset) is subtracted from the weighted input sum, and the activation function is defined accordingly:

$$S = \sum_{i=1}^n (w_i x_i) - \theta$$

$$f(s) = \begin{cases} 0, & s < 0 \\ 1, & s \geq 0 \end{cases}$$

The offset is typically modeled as an additional input with a constant value of 1, associated with its own weight. This structure allows for interpretation of the input-output relationship based on the inverse of the threshold.

As the parameter sss increases from 0 to 1, the sigmoid function outputs values clustered around 0.5. The steepness of the function is determined by parameter aaa , which is always positive. As aaa decreases, the sigmoid curve flattens, and at the limit $a \rightarrow 0$, the sigmoid becomes a step function (Heaviside). Examples of activation functions include:

- (a) step function
- (b) linear threshold
- (c) logistic (sigmoid) function
- (d) hyperbolic tangent with zero threshold

It is worth noting that the sigmoid function is differentiable over the entire real axis – a key feature used in backpropagation and other learning algorithms. Moreover, it enhances weak input signals and prevents saturation caused by strong inputs, aligning with areas of steep slope in the sigmoid curve.

A formal neuron (Fig. 2) is an element used in neural network nodes. The mathematical model of a formal neuron can be expressed by the equation

$$y = f(g) = f(w_1 x_1 + w_2 x_2 + \dots + w_n x_n + \theta)$$

If y is a quantity that provides the activated general nonlinearity, then g is a variable argument; y is the output signal of the neuron; $f(g)$ is the function of the neuron output block; W_i is a constant weight coefficient of the i -th input; x_i is the i -th input signal; the initial state (excitation) of the neuron; $i = 1, 2, 3, \dots, n$ – number

1. Methods for creating intelligent systems

neuron input; n - the number of inputs, depending on the drawing. This expression can be related to the structural diagram of the formal neuron, shown in

The formal non-argument scheme includes input blocks of multiplication by coefficients W_i , one addition and an output block of functional transformation, the function performed by the activation output (excitation function or transition function). The coefficients and synaptic or interneuron coefficients are called

$w_1 < s < w_2$.

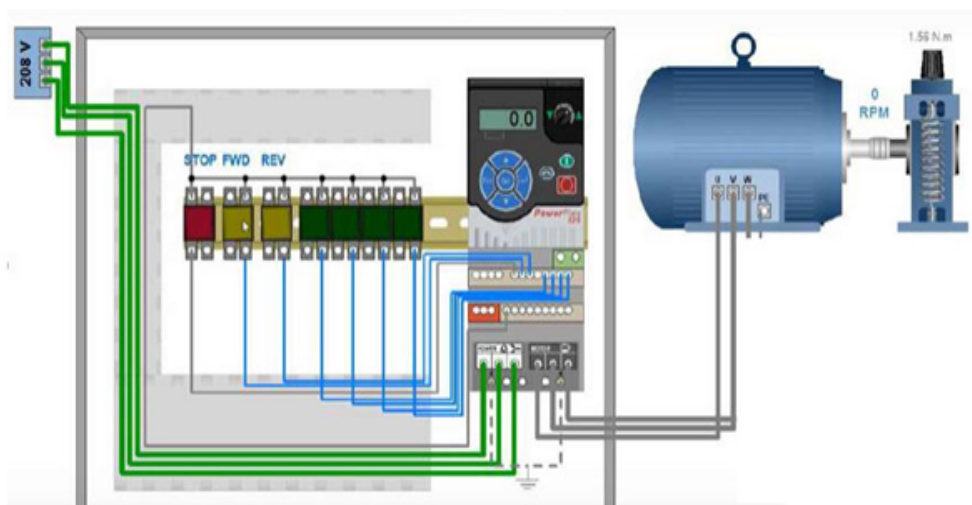


Figure 2: Connection diagram of executive mechanisms and control controllers.

The functional block diagram of a formal neuron consists of both analog and digital signal processing units, forming a unified system often referred to as a functional neuron. This structure includes communication channels for transmitting both analog and digital information.

A formal neuron can be represented using two functional modules (FMs):

- The first module (FM_1) performs input processing and weighted summation.
- The second module (FM_2) applies the activation function, producing the final output.

A basic example of this structure is a module that calculates the weighted sum of neuron inputs:

Such a module does not require an external start condition. It is activated automatically once all input characteristics—i.e., the input variables x_{i1} and x_{i2} and the synaptic weights w_{i1} and w_{i2} —are defined. The output is a scalar value representing the weighted sum, which is then processed by the activation function to yield the neuron's final output.

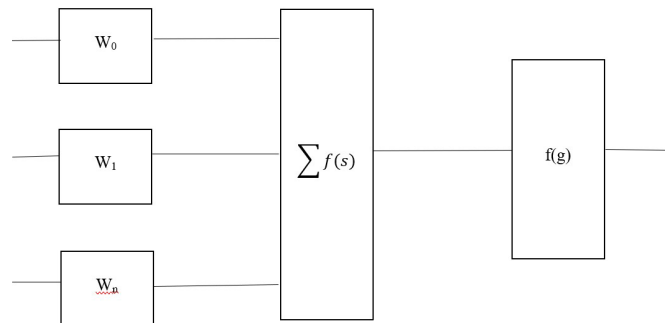


Figure 3: Structural diagram of a formal neural network.



Figure 4: Control of executive mechanisms of intelligent systems using neural networks.

CONCLUSION AND SUGGESTIONS

In the development of intelligent systems, it is essential to begin with a thorough analysis of the processes and the operating environment within industrial enterprises. This analysis must consider both the potential economic benefits and risks before making informed decisions. When there is a need for rapid and responsive control of executive mechanisms in industrial settings, particular attention should be paid to the reliability and efficiency of communication lines to ensure real-time connectivity with these mechanisms.



Assigning tasks to executive mechanisms that exceed their designed thresholds can endanger the entire operational process. To mitigate such risks, commands sent to the executive mechanisms should be filtered through a neural network. This network sequentially analyzes the potential impact of the command on future system parameters, and only after sufficient verification is the command executed. This approach enhances the responsiveness and safety of control in emergency conditions.

The continuous advancement of science and the integration of artificial intelligence (AI) into industrial automation underscore an urgent need to adopt intelligent technologies in production environments. Machine learning methods, when applied to industrial automation, enable the use of intelligent execution mechanisms and adaptive algorithms that significantly accelerate control processes, enhance decision-making, and optimize production efficiency.

These developments represent solutions to critical challenges in modern industry and are closely aligned with the concept of smart factories—core components of the Industry 4.0 paradigm. This includes the integration of cyber-physical systems, real-time data processing, and the establishment of management principles based on knowledge-based information systems. The transition to such advanced frameworks is not only a technological imperative but a strategic necessity for the competitive and sustainable development of industrial enterprises.

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