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INNOVATIVE CONCEPT OF TECHNOLOGICAL DEVELOPMENT

An Innovative Concept for the Development of Smart Facilities Using Artificial Intelligence and Artificial Neural Networks

2026

Arrow Science & Technology

DOI: 10.29013/ICTD.ZhangYang.26.2026

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Innovative Concept of Technological Development / Zhang Yang, – Urbana : Arrow Science & Technology, LLC – 2026. – 26 p.

ISBN 978-1-967596-40-9

The design and logistics associated with the formation, technological development, manufacturing, and construction of smart investment facilities and integrated investment complexes, together with their innovative software-based infrastructure components, are aimed at achieving the highest possible levels of technological, economic, and commercial efficiency while ultimately ensuring environmentally sustainable processes throughout the entire life cycle of development, construction, and operation. Under current technological conditions, these processes are increasingly based on the application of artificial intelligence (AI) and artificial neural network (ANN) technologies.

The significance of achieving the Ideal Final Result (IFR) through the comprehensive application of digital forecasting, computer simulation, engineering design, construction, and operational management lies in establishing an integrated framework for the planning, design, manufacturing, and commercialization of smart investment facilities and their infrastructure. This framework encompasses advanced engineering solutions, including innovative composite materials, laser technologies, technological systems for food production, medical technology applications, and wastewater regeneration and recycling facilities. Such integrated technological solutions are designed to ensure full compliance with applicable international, national, and industry-specific technical standards while maximizing technological performance, commercial viability, and long-term environmental sustainability.

Keywords: *Design and logistics of formation and technological development; characteristics of the design and logistics of formation and technological development; principles for achieving the Ideal Final Result (IFR); smart investment facility infrastructure; examples of technological systems for the production of cosmetic products and the implementation of medical technologies; examples of technological systems for wastewater regeneration and recycling; organizational strategy; employee motivation system; methodology and fundamental principles for developing integrated individual and team-based innovation motivation systems*

Subscribe to print 07/21/2026. Format 60×84/16.
Offset Paper. Arno Pro. Pec. liter. 14. Circulation of 300 copies.
Typeset in Arrow Science & Technology, LLC, USA.

Publishing by Arrow Science & Technology, LLC
805 Silver St., Urbana, IL 61801

ISBN 978-1-967596-40-9

Contents

Reliability of modern multifunctional systems and the potential of TRIZ and ARIZ and their subsequent modifications to improve its level

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Methodology and fundamental principles for developing a systematic innovation-oriented framework for group and individual motivation of employees and project managers in large corporations.

2. System for the distribution of managerial authority in the implementation of the project-based approach.

System and economic–technological principles for the distribution and specialization of the full range of managerial authority in implementing a project-based approach to adapting corporate strategic development plans within an innovation-driven economy, including as a consequence of the globalization of market relations.

Pilot formulations of the innovative concept for the new scientific field are presented below:

1. **Integrative comprehensive concept for the development of targeted project management in an innovation-driven economy.**

2. **Synthesis of techniques and methods for the optimal organization of management for the targeted stimulation of entrepreneurial activity.**
3. **Project methods and techniques for economically stimulating innovation activity, taking into account the specific features of the patent and licensing strategy for a particular project.**

Reliability of a technical system, and especially the reliability of a complex hierarchy of technical local segments, some of which are software-based and are closely interconnected with the system elements of higher hierarchical levels, is today described by numerous concepts and definitions, integrating which into a coherent understanding of the actual situation is extremely difficult and, in most cases, practically impossible.

Recently, approaches have emerged that propose identifying, from among all the local components of the integrated reliability of such a system, those elements that determine the reliability of its most critical components, to a certain extent by relying on the comprehensive reliability of the entire system.

Thus, when designing aircraft, engineers proposed treating failures as inevitable and developed a new approach to aircraft design. The researchers' work has been accepted for publication in the *Journal of Aircraft*, and a brief summary can be read on the Massachusetts Institute of Technology website.

The difference in the new approach is that, during the design process, the engineers did not seek to optimize the aircraft solely in accordance with its intended function, but focused primarily on the failures that could occur within it.

To achieve this, the researchers analyzed statistics on individual failures and determined the probability of their occurrence.

For each individual failure – from a burned-out light bulb to engine failure – its impact on the aircraft as a whole, its controllability, and its aerodynamics was modeled.

As a result of this analysis, the engineers obtained a tree of mutually influencing failures, on the basis of which they could determine which specific components should be modified.

As an example, the engineers analyzed the failures of a small 12-seat military aircraft for which detailed breakdown statistics were available.

It was found that, in the case of certain failures, changing the aircraft's geometry could significantly improve its safety. For example, in the event of rudder failure or the failure of one engine, a model with a larger tail would behave more stably.

Changing the geometry would make the aircraft less aerodynamically efficient, but significantly more reliable.

The proposed approach could, for example, be useful in the development of unmanned aerial vehicles that cannot land for repairs and must continue flying at all costs.

This is how aircraft used to study Antarctica are forced to operate, since there are neither airfields nor maintenance personnel there.

In analyzing the situation, let us return to the tools of TRIZ and ARIZ, which were created specifically to overcome complexes of contradictions of this kind and degree of complexity.

The theory of inventive problem solving includes a special program for solving difficult problems. This program divides the solution process into approximately 50 consecutive steps. It includes special steps that help overcome psychological inertia. The program also has extensive informational support. This program is called ARIZ – the algorithm for inventive problem solving.

Initially, the "methodology of invention" was conceived as a set of rules such as: "to solve a problem means to identify and overcome a technical contradiction" or "the stronger the solution, the lower the expenditure of substance, energy, space, and time."

The emerging "methodology of invention" also included certain standard techniques: segmentation, combination, inversion, changing the state of aggregation, replacing a mechanical scheme with a chemical one, and so on.

The main sources used to identify rules and techniques were information about the work of great inventors, personal inventive practice, and materials on the history of technology.

By the mid-1950s, the conviction had formed and strengthened that inventors, even the most capable ones, worked using the inefficient trial-and-error method and that, consequently, attempts to uncover and apply the "secrets of creativity" were futile.

A fundamentally new "methodology of invention" had to be developed, based on the objective laws governing the evolution of technical systems. These laws could be identified through the systematic analysis of large volumes of patent information.

By the end of the 1950 s, it had become clear that the "methodology of invention" should include not only ARIZ, but also a section on the laws governing the evolution of technical systems and a continuously expanding information database.

The "methodology of invention" was to give way to the "science of invention."

This idea met with strong resistance. The "methodology of invention" was regarded as something more or less tolerable:

after all, it consisted of useful recommendations based on studying the experience of inventors and did not openly overthrow any "sacred" concepts.

The "science of invention," however, challenged what was considered "sacred" – it denied the exceptional nature of great inventors and questioned the traditional belief that the creative process was unknowable.

The "methodology of invention" helped people experience "insight," while the "science of invention" rejected the entire old technology and denied the role of innate abilities. At the time, this was regarded as pure heresy.

Over the years, this program became more rigorous and more clearly defined. During the analysis process, the operational zone and the contradictory requirements imposed upon it were identified, forming the prototype of the physical contradiction.

The size–time–cost operator was introduced. Work on the table for eliminating technical contradictions was completed, and the list of inventive principles was expanded – first to 40 and then to 50. Instructions for completing the steps, notes, and examples were introduced. The main operators formed an integrated system – the interconnection between the steps was strengthened, and a new section appeared for the preliminary evaluation of the proposed idea.

However, over the years, the situation also changed fundamentally because processor-based technology emerged, forcing a completely different approach to the concept of reliability. The rigid, mechanical understanding of reliability was replaced by a more flexible one due to more precise control of processes and operating cycles through the analytical and monitoring capabilities of processor-based technology.

The following principal directions can be identified in the evolutionary development of TRIZ and ARIZ with regard to the synthesis and modification of integrated technical solutions, one of whose fundamental basic indicators is the integrative reliability of the system:

1. A traditional direction in the evolution of ARIZ is the overall increase in the degree of algorithmization through a more comprehensive and deeper application of the objective laws governing the evolution of technical systems, including processor-based systems.
2. A significant strengthening of the "bridge" between the physical contradiction and the method of its resolution, including approaches based on the use of composite materials and the latest advances in digital technology.
3. The expansion of the information base and the strengthening of the links between ARIZ and standards, including the integration of operational industrial standards with environmental standards, whose requirements and constraints conflict with traditional economic norms.
4. The separation of the second part of ARIZ (the development and implementation of the identified solution) into an independent algorithm incorporating such components as hardware, software, system, and method.
5. The development of a new initial stage (or a separate algorithm) for identifying new composite and integrative problems.
6. The strengthening of the educational function. ARIZ should more actively foster the development of strong, comprehensive systems thinking.

7. The gradual expansion of universality in the process of creating a composite model of a device or process that is closely integrated with software and processor-based technologies.

New Smart Manufacturing Technologies (including methods and equipment for non-contact resonant spectrometric monitoring; examples include various highly efficient electrochemical processing technologies, including high-speed metallization techniques and the extraction of water from air).

At the current stage of development of manufacturing processes, characterized by the extensive integration of digital technologies and new composite materials into classical methods of processing raw materials, it is extremely important to make proper use of these additions and to fully exploit the advantages they offer in achieving the ideal final result.

As is well known from classical TRIZ (Theory of Inventive Problem Solving) and its further development – ARIZ (Algorithm for Inventive Problem Solving) – an innovative approach to the systematic development of manufacturing processes provides a wide range of tools whose combined application makes it possible to approach the ideal final result that is most closely aligned with the ideal characteristics of each specific technology or device.

The introduction of new components into engineering schemes and fundamentally innovative solutions has made it possible, provided that the integration method is appropriate and the application options are selectively chosen, first, to redefine the very concept and criteria of the ideal final result, and second, to refine both the criteria and the characteristics that define the ideal final result itself.

In the context of the globalization of manufacturing processes and the transition of the world's most developed economies to an innovation-driven model of development and operation, it must be recognized that, in order to properly adapt to these new and not always favorable manufacturing trends, it is necessary to redefine both the principles governing the organization and formation of the manufacturing process itself and the declared goals and objectives of that process.

In some countries, this new approach to manufacturing, which incorporates the latest technological advances and capabilities to enhance every stage of production as well as the initial requirements for the development of manufacturing equipment, has been designated as **New Smart Manufacturing Technologies**.

Experience gained from the initial stages of developing, designing, and, most importantly, implementing these so-called New Smart Manufacturing Technologies in industrial production has shown that this process tends to expand gradually, extending the application of original innovative technical solutions to an ever-widening range of complex manufacturing tasks.

This expansion follows a fan-shaped pattern, progressively spreading to numerous related processes involving both manufacturing operations and all supporting activities, such as inspection and quality control.

A representative example is the gradual adoption of non-contact, real-time monitoring technologies, which can confidently be classified as smart technical solutions that fundamentally transform inspection techniques and technologies while continuously improving measurement accuracy.

The implementation of this technology began in agriculture, where the need for such monitoring was driven by new operating conditions and increasingly stringent requirements for water quality, particularly in irrigation projects.

Given its immediate relevance and practical demand, the implementation process initially focused on monitoring acidity levels.

1. Monitoring of acidity levels – the following characteristic features were taken into account and considered:

The monitoring range for acidity levels in water and aqueous solutions using non-contact resonant monitoring methods is unlimited.

The monitoring accuracy can be adjusted depending on requirements, but it is no less than 0.1 units of acidity measurement adopted in accordance with the standard.

The monitoring accuracy does not depend on the concentration of organic substances in the water or aqueous solution and is also unaffected by the aggressiveness of the aqueous solution, since all monitoring operations are performed remotely, without any contact with the liquid being monitored.

Because the highest water consumption occurs in irrigation systems, where fertilizers and other chemical reagents are added to the water, the next expansion of the technology's application involved monitoring the concentration of nutrients and fertilizers in aqueous irrigation solutions.

When the substances to be added to the nutrient solution are known in advance, the integrated sensor incorporates a number of selective sensors corresponding to the number of components in the solution.

Each of these sensors is calibrated to detect one component.

The measurement accuracy is within 0.5 milligrams per liter.

Because the conductivity of water and aqueous solutions largely determines their quality, the next expansion involved implementing the technology in the monitoring of the conductivity of water and aqueous solutions.

2. Monitoring of the conductivity of water and aqueous solutions.

Conductivity monitoring is similar to acidity level monitoring.

For successful implementation, a measurement accuracy of within 1 millivolt is sufficient.

The logical continuation of the implementation process was the development of methods and techniques for comprehensive combined monitoring of the quality of liquids and aqueous solutions.

3. Comprehensive combined monitoring of the quality of liquids and aqueous solutions.

Two methods are proposed for comprehensive monitoring.

The first monitoring method involves the use of only one sensor, which indicates a comprehensive water or liquid quality parameter.

The second method involves installing a number of sensors corresponding to the number of parameters or materials being monitored, with each sensor monitoring the condition or concentration of only one material.

The success of the third stage of the technology's expansion determined the strategy for its further application in monitoring the concentration of heavy metals in liquids and aqueous solutions.

4. Monitoring of the concentration of heavy metals in liquids and aqueous solutions.

Monitoring may be performed in a general form; in this case, the sensor indicates the presence of all metals in the water or aqueous solution.

Monitoring may be performed selectively; in this case, the integrated sensor module must include sensors configured to monitor the concentration of each metal individually.

The sensor module may include sensors for comprehensive monitoring of the condition and quality of water or an aqueous solution, including the simultaneous monitoring of all qualitative parameters of the water or aqueous solution.

Because organic substances are currently used as a component of aqueous process solutions in many processes, the logical continuation of the expansion of non-contact measurement technology was its further implementation in monitoring the level or concentration of organic substances in aqueous process solutions.

5. Monitoring of the level or concentration of organic substances in aqueous solutions.

Monitoring of the concentration of organic substances may be general – for example, indicating the total concentration of all organic materials and compounds in water or an aqueous solution.

Monitoring of the concentration of organic substances may be selective; in this case, the integrated sensor module must include selective sensors configured for each individual organic component.

The methodology for monitoring biological components in water or an aqueous solution, owing to the complete absence of contact during measurement, eliminates measurement distortion.

Although numerous instruments and technologies are available for temperature monitoring, the non-contact monitoring method makes it possible to implement an active temperature monitoring system in production lines of any degree of complexity. Most importantly, it does not require inserting a temperature sensor into, for example, an electrochemical reactor or any other equally complex chemical reactor.

6. Temperature monitoring of aqueous solutions.

Temperature monitoring of aqueous solutions is analogous to conductivity monitoring.

For the use of water and aqueous solutions in advanced manufacturing processes, particularly in photolithography production lines, including those involving silicon wafers, the dielectric permittivity parameter is of critical importance, especially for the automatic monitoring of process quality. Consequently, this group of technologies was further extended to systems and methodologies for monitoring the dielectric permittivity of water and aqueous solutions.

7. Monitoring of the dielectric permittivity of water and aqueous solutions.

Monitoring of the dielectric permittivity is analogous to monitoring the level or concentration of organic substances in water or aqueous solutions.

All monitoring options are implemented using selectively configured sensors or groups of sensors installed on the outer surface of the pipeline or supplied together with a pipeline section designed for integration into an existing pipeline.

During the implementation of the project, software will be developed to identify sensor signals and interpret the concentration of the monitored parameter in water or an aqueous solution.

During the implementation of the project, a range of sensor sizes will be developed for installation on pipelines with diameters ranging from 10 to 120 millimetres.

During the implementation of the project, the sensor manufacturing technology will be optimized to achieve an acceptable cost for comprehensive water and aqueous solution quality monitoring systems for agricultural applications.

The further development of sensor designs and monitoring methodologies has made it possible to consider the creation of applications for a dedicated instrument for the non-contact monitoring of compliance of drinking water with environmental and public health standards.

8. Applications of the instrument for the non-contact monitoring of drinking water compliance with regulatory standards.

The instrument is available in two primary configurations. The first configuration is intended for permanent installation directly on the pipeline upstream of the tap within residential premises. The second configuration is portable and is designed for collecting a water sample from the tap into a short section of pipeline on which the sensor is installed.

Both product configurations feature a simple, streamlined design. They are manufactured from plastic, typically polyvinyl chloride, and are compact and easy to use.

The operating principle of both configurations is based on comparing the reference signal of the resonant sensor with the signal obtained from the sample measurement.

The reference signal is obtained using water that fully complies with applicable standards. The instrument sensor detects even the slightest deviation from the reference signal. The detection threshold is 0.000000005 grams per litre for metals; 0.000000000001 grams per litre for radioactive isotopes; 0.000001 grams per litre for hardness salts and silicates; and 0.0000001 grams per litre for organic acids and compounds, including phenols, as well as traces of surfactants, detergents, and mineral fertilizers. All concentrations are expressed per litre of water.

The instrument does not identify or selectively detect each individual contaminant or impurity. However, owing to its high sensitivity, it detects contamination levels corresponding to 50% of the concentration considered hazardous to human health in drinking water. Such a high level of accuracy for a household instrument makes it possible to continuously monitor the quality of water used for domestic purposes and to take corrective action before contaminant concentrations reach hazardous levels.

Public health standards in most developed countries recommend continuous monitoring of drinking water quality. The implementation of this recommendation has been hindered by the absence of a reliable, easy-to-use, and accurate instrument at a price suitable for widespread purchase and use.

The proposed instrument configurations fully comply with applicable standards, both in terms of the safety of the materials used and their operational performance.

Both configurations are readily manufacturable, require no specialized production technologies, and can be produced under the conditions of relatively small manufacturing enterprises while maintaining an economically acceptable price.

This makes regional manufacturing feasible, that is, assembly at the point of sale. Such an approach reduces transportation costs and enables direct distribution without warehousing, thereby eliminating inventory storage costs.

The foregoing demonstrates that the introduction of so-called smart elements of manufacturing technology within one technological field immediately creates demand for their application in other fields and other groups of technologies.

To further illustrate this phenomenon, the following example is proposed: the application of the innovative smart technology of high-speed metallization as the core technology for seawater desalination, replacing the conventional reverse osmosis membrane process.

In this approach, saline water, seawater, or saline groundwater is treated as an electrolyte during the desalination process, and the electrical deposition of dissolved salts from this electrolyte is carried out as a high-speed electrochemical reaction within a directed electrolyte flow.

This approach to the electrochemical integration of conventional processes within an innovative technological framework combines electrodeposition technology with desalination technology without the use of reverse osmosis.

This, in turn, makes it possible to distribute key engineering solutions among simplified local subsystems, significantly increasing the reliability of individual system components. Moreover, these local solutions are structurally simpler and do not create localized sources of failure. Such an integrated system architecture substantially reduces the likelihood of failure events and significantly lowers the maintenance costs of the overall supersystem.

Biomechanics and technology of non-contact monitoring and real-time monitoring. The significance of incorporating these developments into innovation processes

Online and real-time monitoring of assigned task execution, combined with the accuracy and sensitivity of the sensor module across various types of monitoring of materials, composites, and processes, makes it possible to solve a wide range of problems related to the control of modern supersystems operating in a fully automated mode, provided that artificial intelligence and artificial neural network components are incorporated into their electronic modules and subsystems.

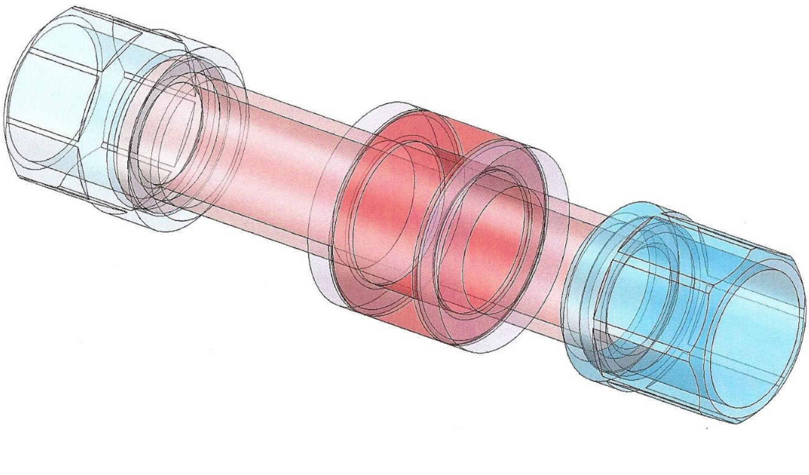

Figure 1. The schematic diagram and model of an electromagnetic resonant sensor for measuring the flow velocity of a liquid in a pipeline

In modern specialized process equipment, all sensors integrated into its assemblies and units can operate on the principles of advanced electromagnetic resonance spectroscopy, with minimal energy consumption and maximum accuracy, while the frequency and duration of measurement operations remain within several milliseconds.

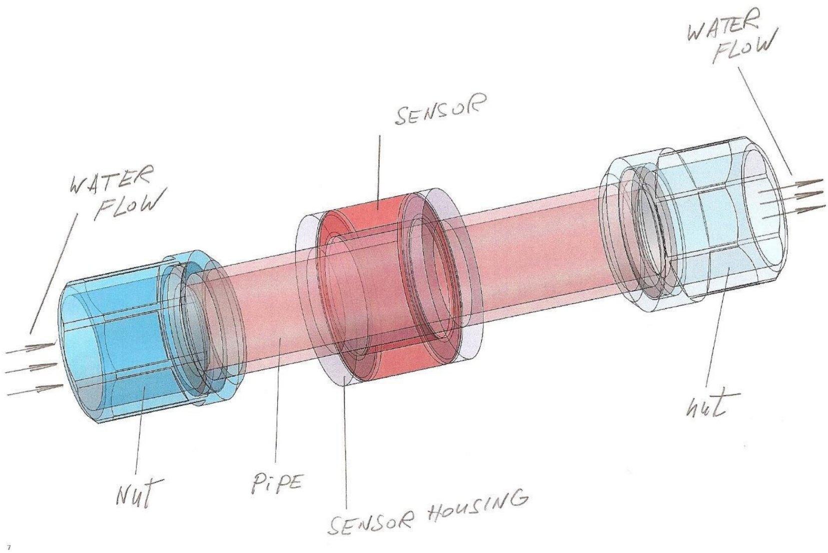

Figure 2. The figure also shows the schematic diagram and model of an electromagnetic resonant sensor for measuring the flow velocity of a liquid in a pipeline

Modern technologies for manufacturing ultra-pure products, various processes in microelectronics, pharmaceuticals, and many other breakthrough technologies require increasingly accurate and, most importantly, continuous monitoring equipment that operates without contact with the object being measured.

Biomedical technologies require simpler technological monitoring solutions, one of the principal requirements of which is the ability to operate stably and accurately without direct contact with the monitored object.

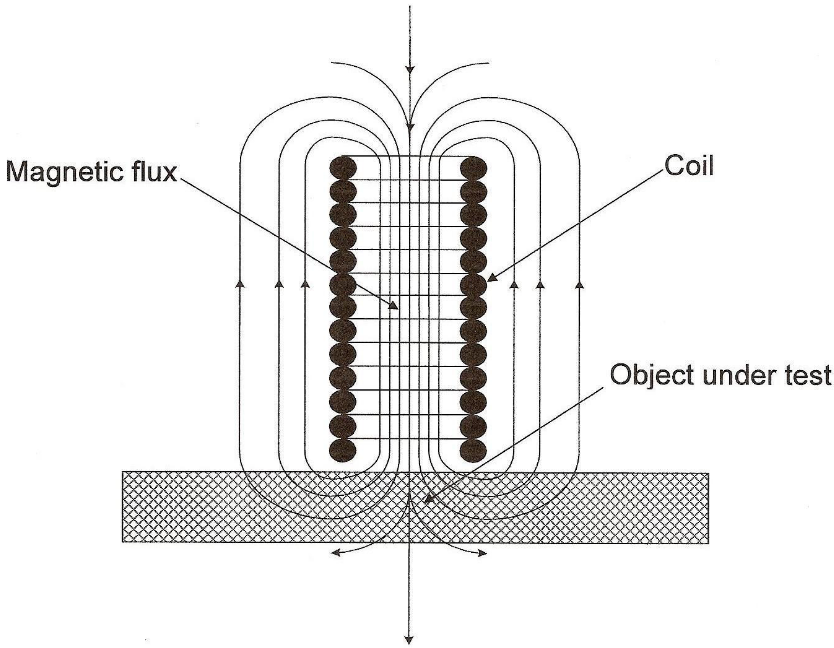

Figure 3. The schematic diagram of a sensor based on a conventional coil

In recent years, the most widely performed measurement procedures, such as blood analysis and rapid blood analysis, have increasingly been simplified and conducted without intervention in the monitored environment.

Robotic devices require increasingly advanced sensors for feedback systems, compelling inventors and innovative interpreters of biological objects to continuously seek analogous solutions to their problems in modular natural biomechanical systems and in more complex, multifunctional bio-integrative composite systems.

The following are some of the most successful examples of such solutions.

Engineers have developed a flexible device that simulates the sensation of touch. A description of the device was published in the journal *Nanotechnology*.

The device consists of gold electrodes mounted on a flexible polymer. To fabricate the electrodes, the researchers deposited a layer of gold onto a thin silicone strip, after which the resulting "sandwich" structure was mounted on a mesh made of an elastic polymer. The polymer with the electrodes was then transferred onto a thick silicone substrate, and the completed device was turned inside out so that the gold electrodes were positioned on the inside.

According to the developers, when a finger is inserted into the device, the current passing through the electrodes produces a tingling sensation in the fingertip. The authors state that, by controlling the current, it will be possible in the future to simulate contact with surfaces of different textures, as well as sensations of warmth and cold.

The work primarily concerns the fabrication methodology for the flexible device and the attachment of the electrodes, rather than the control of electrical stimulation. Additional research will be required to enable the transmission of different textures and tactile sensations.

Earlier, another group of engineers presented a device that performs the opposite function – a touch sensor. Its design was inspired by the structure of the hair-like elements that secure the elytra of beetles. The sensor's two plates, covered with fine hair-like structures, proved to be highly sensitive to pressure because pressure altered the contact area between them.

Very often, the exceptional sensitivity of such engineered equivalents of natural biological objects surpasses all existing expectations.

Engineers have developed a highly sensitive touch sensor capable of distinguishing pressure, shear, and torsion. The work was published in the journal *Nature Materials*, and a summary was reported by Nature News.

The scientists were inspired by the mechanism that secures the elytra in certain beetle species. It consists of fine hair-like structures that interlock when the beetle's elytra are closed and at rest.

To some extent, this system resembles hook-and-loop fasteners, with the difference that it contains no hooks – the hair-like structures adhere to one another solely through surface interactions.

The sensor developed by engineers at Seoul National University is based on the same principle. It consists of two polymer plates bearing hair-like structures approximately one micrometre in height and ten times smaller in diameter. The hair-like structures are coated with a thin metallic layer, making their surfaces electrically conductive.

The two plates are joined together with their hair-covered surfaces facing one another and connected to a resistance sensor. Electric current can pass relatively freely from one plate to the other, while the electrical resistance depends on the total contact area between the hair-like structures. Even the slightest change in the position of the hair-like structures alters the electrical resistance, which forms the basis of the sensor's operation.

References

1. Zhao, X., et al. **Method and Apparatus for Video Coding.** United States Patent Application **US 20190281321 A1**, September 12, 2019.
2. Chen, Y., et al. **Sharing of Motion Vector in 3D Video Coding.** United States Patent Application **US 20190281270 A1**, September 12, 2019.
3. Yin, H., et al. **Method and System of Neural Network Loop Filtering for Video Coding.** United States Patent Application **US 20190273948 A1**, September 5, 2019.
4. Haque, M., et al. **Video Coding System with Temporal Scalability and Method of Operation Thereof.** United States Patent Application **US 20190273932 A1**, September 5, 2019.
5. Chun, J., et al. **Data Transmission Method in Wireless Communication System and Device Therefore.** United States Patent Application **US 20190268098 A1**, August 29, 2019.
6. Jansson Toftgård, T., et al. **Methods and Devices for Vector Segmentation for Coding.** United States Patent Application **US 20190268016 A1**, August 29, 2019.
7. Luo, N., et al. **Method and System of Video Coding with Reduced Supporting Data Sideband Buffer Usage.** United States Patent Application **US 20190261010 A1**, August 22, 2019.
8. Zhao, L., et al. **Method and Apparatus for Using an Intra Prediction Coding Tool for Intra Prediction of Non-Square Blocks in Video Compression.** United

States Patent Application **US 20190253706 A1**, August 15, 2019.
9. Wang, Y., et al. **Adjusted Fractally Enhanced Kernel Polar Codes for Achievable Signal-to-Noise Ratio Spike Mitigation.** United States Patent Application **US 20190181979 A1**, June 13, 2019.
10. Tsai, Y.-T., et al. **Method and Image Processing Apparatus for Video Coding.** United States Patent Application **US 20190182503 A1**, June 13, 2019.
11. Mittal, U., et al. **Coding Main Beam Information in CSI Codebook.** United States Patent Application **US 20190190578 A1**, June 20, 2019.
12. Li, B., et al. **Coded-Block-Flag Coding and Derivation.** United States Patent Application **US 20190200025 A1**, June 27, 2019.
13. Hannuksela, M. M., et al. **Video Coding and Decoding.** United States Patent Application **US 20190222863 A1**, July 18, 2019.
14. Lainema, J., et al. **Apparatus, a Method and a Computer Program for Video Coding.** United States Patent Application **US 20190200026 A1**, June 27, 2019.
15. Ugur, K., et al. **Apparatus, a Method and a Computer Program for Video Coding and Decoding.** United States Patent Application **US 20190208222 A1**, July 4, 2019.
16. Chuang, T.-D., et al. **Method and Apparatus of Current Picture Referencing for Video Coding.** United States Patent Application **US 20190222859 A1**, July 18, 2019.
17. Tanner, J., et al. **Video Cluster Encoding for Multiple Resolutions and Bitrates with Performance and Qual-**

ity Enhancements. United States Patent Application **US 20190230365 A1**, July 25, 2019.