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DESIGN OF EQUIPMENT INCORPORATING ARTIFICIAL INTELLIGENCE AND NEURAL NETWORK ELEMENTS. (Laser and optoelectronic systems for a smart family physician's office, incorporating elements of artificial intelligence and neural networks, with the prospect of a gradual transition to quantum computing technologies)

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Abstract

The design features of laser and optoelectronic systems and multi-level instrumentation are considered in the context of integrating artificial intelligence and artificial neural network elements into their control and monitoring modules, including the prospective transition to quantum computing technologies and their equivalents.

A complex set of fundamentally new and previously uncommon conditions and requirements across all stages of design, production preparation, and integrated manufacturing – aimed at enabling the development of so-called smart production systems, machines, transport, technologies, and intelligent workplaces across industry, medicine, science, education, and agriculture – necessitates a reassessment of established approaches and the search for new organizational and technical solutions to meet emerging challenges.

The paper also addresses the forecasting of development directions and conceptual frameworks for the formation of so-called smart instruments and devices within the technological domain of specialized integrative systems, with particular emphasis on medical devices and advanced disposable instrumentation based on laser diodes and modern fiber-optic technologies.

Strategic importance is attributed to the high-speed identification of smart instruments and devices in real time, particularly under conditions where artificial intelligence and neural network elements are employed within analytical blocks of control and monitoring systems.

Additionally, the reliability of subsystem-level core technical solutions in optical instruments and devices is examined.

Keywords: *Design features of laser and optoelectronic systems; multi-level specialized instrumentation systems; application of artificial intelligence and neural network elements in control and monitoring modules; prospects for a phased transition to quantum computing and its equivalents*

The author of this publication considers it necessary to emphasize the exclusively key role and significant influence exerted by the works of the distinguished specialist in the management and organization of processes related to the development of integrated systems of so-called smart equipment for a smart family physician's office, incorporating elements of artificial intelligence and artificial neural networks – Gulmira Kenzhebayeva – in her forward-looking developments within the core thematic area associated with New Smart Manufacturing Technologies, including technologies intended for application in the environment of a smart family physician's office.

According to Gulmira Kenzhebaeva, particular importance within these processes is attributed to such issues as waste utilization and regeneration of spent technological solutions; recirculation of etching solutions and other process liquids; and the conversion of toxic exhaust gases into harmless liquid forms. Based on the substantiated parameters and performance indicators presented in her research and publications, reflecting the characteristics of the ecosystem of new smart manufacturing technologies, it becomes evident that these systems must incorporate a complex set of fundamentally new and previously uncommon conditions and requirements across all stages of design, production preparation, and integrated manufacturing. These processes are aimed at forming the capabilities and specific features of so-called smart production systems, machines, transport, technologies, and intelligent workplaces across all sectors of industry, medicine, science, education, and agriculture.

These conclusions necessitate a reconsideration of established paradigms and stimulate the search for new organizational and technical solutions aimed at ensuring compliance with newly emerging conditions. The author of this publication considers it important to examine these aspects as a model example within the technological domain of medical equipment for a smart family physician's office, along with its associated materials and technologies.

In order to obtain a sufficiently clear and structured understanding, it is proposed to consider the following directions and issues. These include the forecasting of development trends and conceptual approaches to the formation of so-called smart instruments and devices within the specific technological field of the smart family physician's office, as well as within the broader domain of specialized integrative devices, primarily medical devices and complex disposable instrumentation based on laser diodes and modern fiber-optic technologies.

The strategic importance of high-speed identification of smart instruments and devices in real time is emphasized, particularly under conditions involving the use of artificial intelligence and artificial neural network elements within analytical blocks of control and monitoring systems. The reliability of supersystems of fundamental technical solutions in optical instruments and devices is ensured through increased efficiency and reliability of cooling subsystems achieved by the use of encapsulated composite materials. Furthermore, reliability is enhanced through improvements in installation and mounting subsystems, as well as through the optimization of electronic unit subsystems, utilizing encapsulated composite materials and advanced printed circuit board manufacturing technologies based on hierarchical structuring principles characteristic of RITM technologies and their combinations.

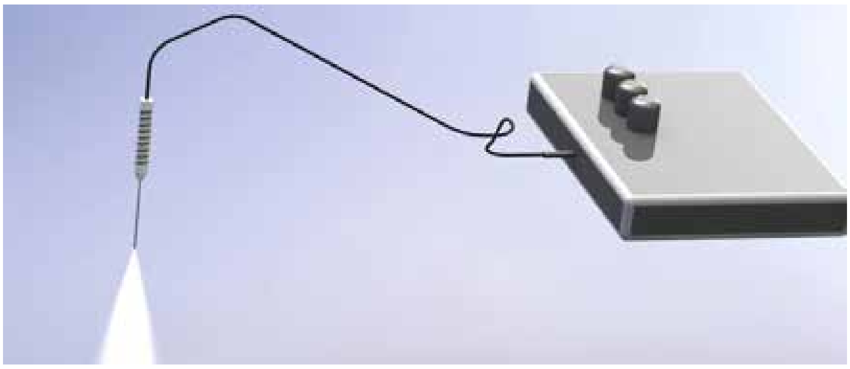
Ensuring the required level of processing speed in control and monitoring units is achieved through the application of advanced thin-film microassembly production methods, including the use of flexible automated manufacturing modules and high-speed galvanic and electrochemical coating techniques, implemented without adverse electrode edge effects and employing electrochemical cells operating under directed electrolyte flow conditions.

The implementation of real-time online monitoring is considered essential at both the supersystem level and the level of interconnected subsystems, utilizing measurement technologies based on electromagnetic emission functions and electrical resistance, as well as advanced high-speed resonance spectroscopy principles. The application of integrated automated assembly systems for electronic components of supersystems and subsystems, including the preliminary stamping of constituent parts and elements, is also of critical importance.

In micro-automation systems, the use of micromotors with high torque characteristics operating on the principles of the inverse piezoelectric effect is proposed. Control of optical parameters of supersystems and subsystems is carried out using advanced mobile applications and devices based on them.

Finally, the manufacturing of components and assemblies of devices, apparatuses, and systems of all levels of complexity – including both supersystems and subsystems – is performed using specialized technological equipment currently in commercial operation at industrial enterprises, ensuring the achievement of all necessary characteristics and parameters required for the classification of smart equipment.

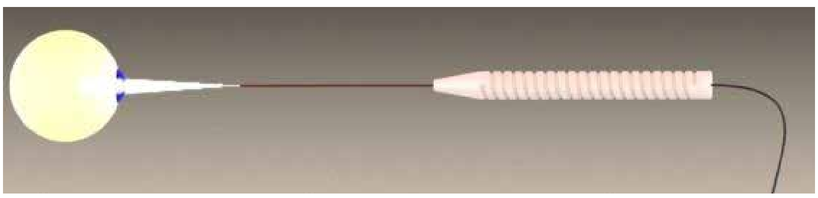
Figure 1. *Illustrates an innovative supersystem of a comprehensive laser instrument intended for ophthalmological applications. The system employs a disposable instrument connected to laser radiation sources via a precision optical cable, with the instrument positioned at one end and an encoding device at the other. The system incorporates luminophores designed to generate the required emission spectrum while simultaneously mitigating the impact of high-intensity, high-concentration laser radiation on the patient's physiological parameters*



It should be noted that, in recent years, innovative integrative combinations of advanced and highly efficient technologies have been developed, enabling – at minimal production costs comparable to those of conventional data carriers and storage media – the creation of supersystems in which information carriers are terabit-level media and their equivalents. The systemic integration of these information carriers with artificial intelligence and artificial neural network elements fundamentally transforms the technical characteristics and capabilities of such supersystems, as well as the hierarchical structures of their constituent subsystems.

These technologies have been developed in parallel by groups of researchers from several countries, including Japan and South Korea.

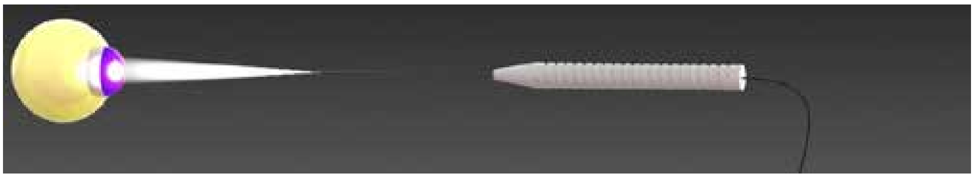
Figure 2. *Illustrates a disposable laser instrument with a radiation scheme directed into the patient's eyeball, in which several optimization conditions and techniques have been implemented to refine the emission parameters and spectral characteristics*



This has been achieved through the use of specialized drivers and optical mixers, enabling the combination of three laser diodes of equal power to produce an optimal radiation profile, spectrum, and output power.

As shown in the figure, the use of a disposable instrument necessitates extremely precise encoding in order to eliminate even the slightest possibility of errors during the configuration and optimization of radiation parameters. Such errors may arise when counterfeit disposable instruments are used, lacking the required calibration parameters and adaptability to the specific conditions of the surgical procedure.

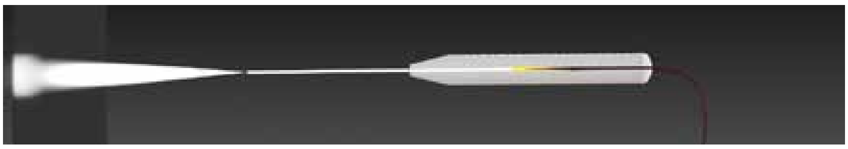
Figure 3. *Illustrates a configuration of a disposable laser instrument which, in conjunction with the optical components of the patient's eyeball, forms regions of optical aberration that facilitate a more adaptive integration of an active high-intensity laser beam within the optical conditions established in the treated eye*



These configurations of optical integration of radiation from the disposable instrument, as part of the innovative supersystem incorporating a comprehensive driver and other components of the ophthalmological laser instrument, are enabled by the presence of a continuous functional interconnection between the driver processors assigned to each of the three laser diodes and the elements of artificial intelligence and artificial neural networks.

The demonstrated configurational flexibility of the overall supersystem allows, in future modifications, for the confident integration of quantum computing technologies and their processor equivalents into control and monitoring systems, potentially in combination or symbiosis with advanced conventional computing and processing architectures, including electronic circuit boards manufactured using RITM technologies (dimension-selective metal etching techniques).

Figure 4. *Also illustrates a variant of a disposable laser instrument which, in conjunction with the optical components of the patient's eyeball, forms regions of optical aberration that facilitate a more adaptive integration of an active high-intensity laser beam within the optical conditions established in the treated eye. In this case, however, part of the adaptive function within the overall process is achieved through the application of various types of luminophores in the processing and coating of the optical cable (fiber)*



These configurations of optical integration of radiation from the disposable instrument, as part of the innovative supersystem incorporating a comprehensive driver and other components of the ophthalmological laser instrument, are additionally determined by the influence of the properties and capabilities of the luminophore. This is combined with the presence of a continuous functional interconnection between the driver processors assigned to each of the three laser diodes and the elements of artificial intelligence and artificial neural networks, which in this case are further tasked with the high-speed, detailed coordination of all factors forming the final technical characteristics of the disposable instrument.

The demonstrated configurational flexibility of the overall supersystem allows, in future modifications, for the confident integration of quantum computing technologies and their processor equivalents into control and monitoring systems, with already demonstrated ultra-high processing speeds. This may be achieved in combination or symbiosis with the most advanced forms of modern computing and processing architectures, including electronic circuit boards manufactured using RITM technologies (dimension-selective metal etching techniques), which – by virtue of their structural design and, in particular, interlayer spacing of approximately 50 microns – can increase processing speed and system responsiveness by orders of magnitude.

Figure 5. *Illustrates an innovative supersystem of a comprehensive laser instrument for ophthalmological applications, operating in the mode of configuration and optimization of radiation parameters*

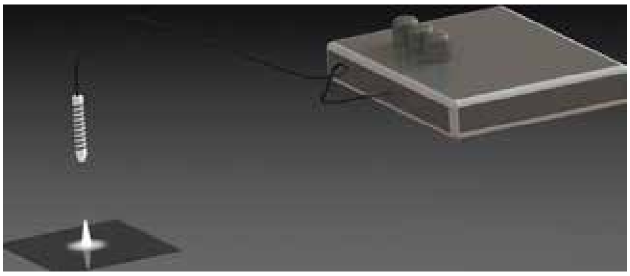
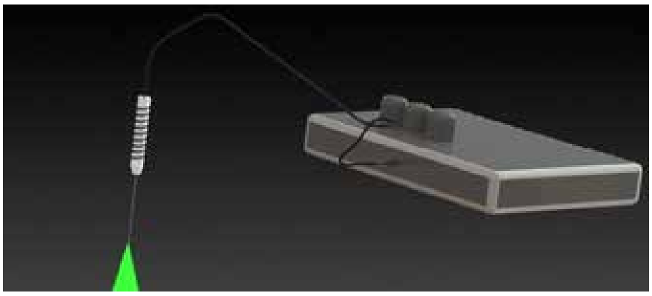


Figure 6. *Also illustrates an innovative supersystem of a comprehensive laser instrument for ophthalmological applications. In this system, three laser diodes operate simultaneously, each emitting radiation of a different wavelength. As in the previous examples, a disposable laser-emitting instrument is employed, which is connected to the specified laser radiation sources and their drivers via a precision optical cable, with the instrument located at one end and an encoding device at the other. The system as a whole incorporates luminophores, the function of which is to generate the required emission spectrum while simultaneously mitigating the impact of high-intensity, high-concentration laser radiation on the patient's physiological parameters*



To demonstrate the degree of novelty of the elements of this technology, it is appropriate to further present information on the foundational inventions from which this group of fundamentally new technologies has evolved.

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