BULGARIAN ACADEMY OF SCIENCES
PROBLEMS OF ENGINEERING CYBERNETICS AND ROBOTICS • 2026 • Vol. **84**, pp. 3-20
p-ISSN: 2738-7356; e-ISSN: 2738-7364
https://doi.org/10.7546/PECR.84.26.01

Some Innovative Solutions Related to the Application of Robotics and Mechatronics in Various Fields of Medicine

Veronika Ivanova[1], *Ani Boneva*[2]

[1]*Institute of Robotics, Bulgarian Academy of Sciences, Sofia 1113, Bulgaria*
[2]*Institute of Information and Communication Technologies,*
Bulgarian Academy of Sciences, Sofia 1113, Bulgaria
Emails: iwanowa.w@abv.bg, ani.boneva@iict.bas.bg

Abstract: The development of robotics as an independent scientific and technical field is constantly revealing new opportunities. Robotic devices have great potential for implementation in processes and tasks that do not require the direct presence of a human. Robotics and mechatronics are also finding their place in various fields of medicine. The main goal of this publication is to offer innovative solutions based on modern advances in robotics and mechatronics. These solutions are related to a wide range of applications, one of these applications is related to various fields of medicine and addresses modern challenges and needs of patients for better healthcare. Surgical robotics is related to the fields of gynecological and urologycal procedures, spinal and orthopedic surgery, general and abdominals surgery – to name just a few arears of application that will be discussed. A system for analysis and control of biological tissues related to tumor treatment, and a system for collecting, processing and visualizing data with application in medicine will be presented in this paper. Finally, the application of the robotics, mechatronics and information technologies in the context of medical education will be introduced.

Keywords: Robotics, Mechatronics, Medicine, Surgical robots, Robotics for egg fertilization, robot nurses, Social robots, Robots in dentistry.

1. Introduction

The development of robotics as an independent scientific and technical field is constantly revealing new advantages and opportunities. Robotic devices have great potential for implementation in processes and tasks that do not require the direct presence of a human in their execution. Progress is accompanied by the use of new approaches and methods in the design and implementation of innovative robotic devices, which implement the achievements of such directions as mechanics, electronics, information technologies and artificial intelligence.

Robotic devices find their place in various areas of medicine. The integration of innovative robotic and mechatronic solutions in medicine leads to a significant improvement in the accuracy, efficiency and safety of diagnostic, therapeutic and rehabilitation processes, while at the same time creating prerequisites for the development of new methods and approaches in healthcare. Here are some areas of medicine where robotics is successfully integrated, they are as follows:

1.1. Surgical robots

Surgical robotic systems include robots and additional techniques and technologies to help surgeons in the operating room perform minimally invasive surgery in the best possible way. These systems increase precision, reduce trauma, and significantly improve outcomes after such surgery. They feature advanced software and excellent technical capabilities.

They are used in the following medical fields Figure 1:

- Gynecological and urologycal procedures
- Spinal and orthopedic surgery
- General and abdominals surgery
- Bariatric and Thoracic procedures.

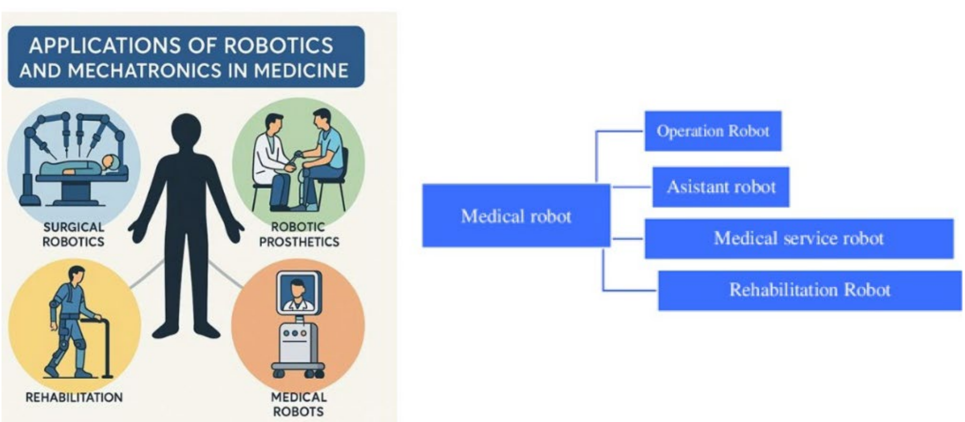

Fig. 1. Application of robotics and mechatroncs in medicine.

Surgical Robot DaVinchi works in Bulgaria from 2007 (Intuitive Surgical, Inc.) [1].

Fig 2. Robotic System DaVinchi (Intuitive Surgical, Inc.) [1].

Robotics in surgical operations solves the following problems: Flexibility is ensured, movement scaling, tremor is overcome, ergonomic position of the operator's body (reduces fatigue), remote implementation of the operation, precise tracking of a set trajectory without affecting healthy tissue. One of the latest achievements of Intuitive Surgical, Inc., is da Vinci SP for single-port surgery. Access is through one hole, reducing trauma to patients, but it is not suitable for complications due to the time delay.

The Hugo™ RAS by [2] is other one. Originally developed for urology and gynecology, Hugo is now used in Europe, America and Asia. Developed using a modular approach, it consists of separate mobile carts on which various robotic arms with a wide range of capabilities are mounted. This achieves space-efficient, adaptive surgical robotics. The Robot system Versius by CMR Surgical UK [3] is applied for general, gynecology, colorectal. Its benefits include Portable size, scalable, and fits for Smal Ooperation Rooms.

The Senhance Robot by Asensus Surgical [4] is used for gynaecology, colorectal. The Senhance characteristics includes haptics to laparoscopy, budget-friendlywith eye tracking, provides surgeons with a more intuitive and data-rich environment. Also suitable for training. The Stryker Robot by Mako SmartRobotics [5] is applied in Orthopedic (hip, knee) surgery. Leading joint replacement system with CT guidance. The system features 3D CT-based preoperative planning and real-time bone modeling to improve precision. Stryker continues to enhance its capabilities with upgrades for implants and imaging. It is preferred for small clinics and same-day procedures. Edge Medical Robotics [6] are in development Designed for Soft-tissue. Capabilities for AI and tactile sensing, AI-driven, force-sensitive robotics.

1.2. Robots for in-vitro procedures

Essentially, it's a robotic update to traditional in vitro fertilization that's faster and has a higher success rate. The current practice is delicate and labor-intensive, and significantly expensive [7].

Fig. 3. Micro/Nanorobotics in In Vitro Fertilization [7].

1.3 Social robotics

Robots working as nurses. As our society ages, there is a great need for medical robots powered by artificial intelligence to provide elderly and sick patients with more personalized and effective healthcare. They are useful in dispensing medications, measuring blood pressure and temperature.

Fig. 4. Robot Nurse [8].

Robotic assistants for moving and caring for patients – preventing injuries to medical staff are shown in Figure 5. Robots also help the elderly– turning on the TV, medicines, food, presenting the news, reading a book, measuring blood pressure and temperature (Figure 6).

Fig.5. Riken – Japanese robot nurse [9].

Fig. 6. Social robot for alder people.

Here, in addition to social robots such as Pepper [10] and ElliQ [11] – which assist elderly people in their daily lives, smart homes with mechatronic sensors can also be included – for monitoring vital signs and preventing accidents.

1.4 Cardiology and internal medicine

- Robotic catheter systems (Sensei, Niobe) [12-13] – for minimally invasive cardiac interventions with high precision.
- Microrobots for intravascular interventions – navigate through blood vessels guided by magnetic fields [14].
- Telemetry devices and mechatronic sensors – continuously monitor parameters such as ECG, blood pressure and saturation, integrated with robotic systems for remote diagnostics

1.5 Robots in dentistry

Robotic systems are used in dental implantology, oral and maxillofacial surgery, prosthetic and restorative dentistry, endodontics, orthodontics, oral radiology, as well as in the processing of dental formations. For example, robotic implant surgery allows increased flexibility, stability and accuracy of implant placement.

The movements performed in dentistry are analogous to movements in milling, drilling, grinding. Robots can perform repetitive work processes for an indefinite period of time, while improving overall quality and reducing the workload and fatigue of dentists [15,16,17].

Fig. 7. A Robot for dentistry.

1.6. Prosthetics and biomechanics

- Bionic limbs (Össur, DEKA Arm, Open Bionics) [18 19 20] – use EMG/EEG signals for control; include haptic feedback sensors;
- Mechatronic implants – integrated with load and temperature sensors for better adaptation of the implants to the body;
- Soft robotics prostheses – made of soft materials that mimic muscle elasticity.

1.7 Diagnostics, telemedicine and laboratory research

- Robotic blood or sample collection systems – precise and safe solutions for automated diagnostics;
- Autonomous laboratories (Lab-on-a-Chip) [21] – miniature mechatronic systems for rapid real-time diagnostics;
- Telemedicine robots (e.g. TUG [22] and RP-VITA-[23]) – mobile platforms that allow remote communication with patients;
- Wi-Fi/IoT-based medical devices – e.g. dual-channel ECG-robotic platforms for remote cardiac monitoring.

Training and simulation

- Robotic simulators – realistically reproduce surgical operations (e.g. SimMan [24], LapMentor [25]);
- AR/VR and mechatronic simulators – combine augmented reality and haptic feedback for training students and surgeons;
- Modular training platforms – for laparoscopic and cardiac procedures.

And of course, these are not all areas of medicine where robotics and mechatronics find their place.

In the next chapter, we present some of our innovative developments solving problems in various areas of medicine. Included are a System for Analysis and Control of the Mechanical Properties of Biological Tissues with Application in Laparoscopic Operations, a Device for a Robotic System for Local Tumor Therapy, a System for Collecting, Processing and Visualizing Data with Application in Medicine, a Platform for Training in Minimally Invasive and Robotic Surgery, a Mobile Electrocardiographic Device, and Processors.

2. Some innovative solutions related to the application of robotics and mechatronics in various directions

2.1 System for analysis and control of the mechanical properties of biological tissues

The first of these is a System for Analysis and Control of the Mechanical Properties of Biological Tissues Figure 8. The system, through controlled movements of a micromanipulator mounted in it, detects anomalous areas in the examined object with the possibility of fixing them in real time. It is designed as an intelligent mechatronic device whose advantage is the determination of the relaxation time parameter.

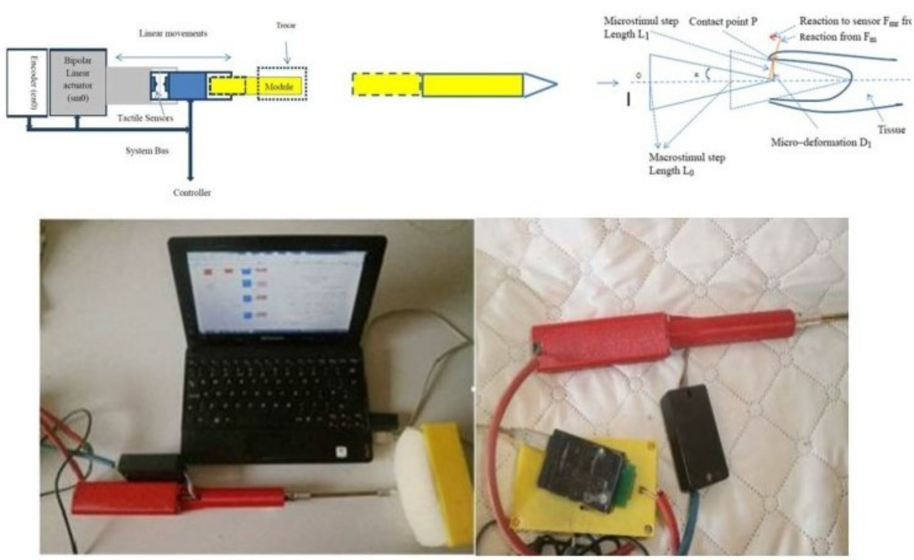

Fig. 8. A system for analysis and control of biomechanical properties of tissues.

This parameter is related to the structure of tissues – their elasticity and viscosity, and the deviation outside the specified values signals the presence of anomalous areas in the studied object. As mentioned above, biological tissues are characterized by the properties of elasticity and viscosity – their deformation depends on the ratio of external forces and they lose part of their energy when they regain their shape.

The method of macro and micro stimulation was applied, where a tool with built-in force sensors was used. The force is measured by the sensors in the direction opposite to the movement of the tool. The movement of the tool is achieved by a series of linear steps of equal length and direction, called macro stimuli [26]. The micro stimuli interact with the tissue and lead to its reaction, which modulates the tension and forms a micro force in the direction opposite to the micro displacement. The total sum of the micro forces (its component in the direction of the tool movement) is recorded by a tactile sensor. This is used in the assessment of the tissue structure.

$$F_c = F_b e^{-(\frac{t}{\tau})} \tag{1}$$

where F_c is the measured value of F for $t > 0$; F_b is the measured value of F at the initial moment ($t=0$); t is the time counted from the beginning of the given macrostimulus; τ is the "relaxation time" and determines the mechanical properties of the tissue and e is the elastic modulus of the tissue.

2.2 Robotics and mechatronics in tumor treatment

The 21st century has seen new and profound knowledge about cancer and significant progress in its treatment. Problems related to the increasing incidence and successful outcome of treatment. Radiation therapy (RT) is used in all types of cancer and is part of the procedure for its treatment. The disadvantages are excessive scattering and irradiation of healthy tissues.

The progress of robotics and mechatronics can be used to optimize tumor treatment by personalizing the therapeutic dose based on clinical parameters and anatomical information. A solution for a surgical robot device in local tumor therapy is proposed – Figure 9, consisting of a diagnostic device, upgraded with a generator that generates a programmed frequency, forms the necessary radio signal and feeds it to an emitter for performing radiotherapy. An electromagnetic field with a pre-programmed frequency and intensity is formed in the patient's body.

The advantage is a gentle local therapy, in which the tumor is under control, while protecting the organs that are close to the diseased tissues. Another significant advantage of the solution is that the device simultaneously studies the biomechanical characteristics of the tissues and applies local tumor therapy, unlike other solutions [27].

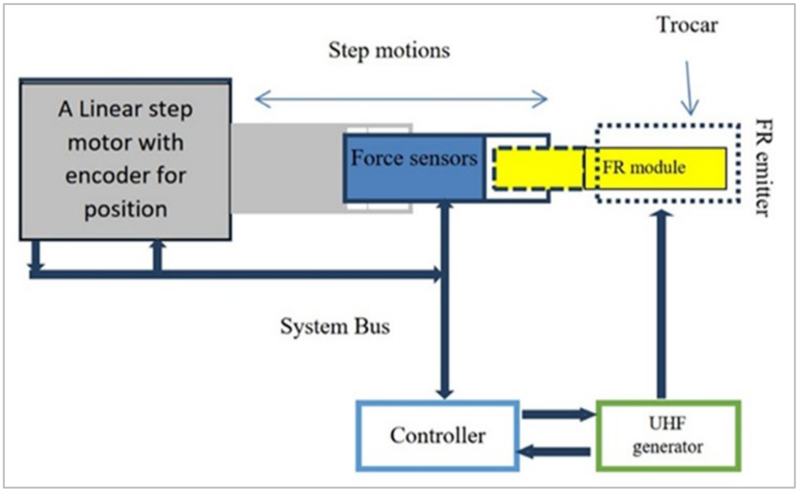

Fig. 9. A Device for a local tumours treatment.

To determine the dose of radiation, we start from the known fact that a unit of measurement is a unit of measurement of the absorbed dose of ionizing radiation received in the system SI e Grey (Gy) (1 $Gy \approx$ 100,185 R (x-ray); 1 Gy 28 $=$ 100 rad (rd)). The received dose is equal to one grey if, as a result of the absorption (acceptance) of ionizing radiation, the substance received (absorbed) one joule of energy per kilogram:

$$1\text{Gy} = 1\frac{\text{J}}{\text{kg}} = 1\text{m}^2.\ \text{s}^{-2}, \quad (2)$$

where: Gy – Grey; J – Joule; kg – Kilogram

Gray, like the sievert unit (international designation Sv) is an SI unit of measurement for the dose of ionizing radiation), and is used to measure the amount of radiation received. A dose of the order of 10÷ 20 Gy taken at once is lethal to humans. This equates to around 750 ÷ 1,500 joules for an adult weighing 75 kg. In medical practice, the multiple unit milligray (mGy) is used because the basic unit is too large. An X-ray, for example, irradiates the person with 1.4 mGy. One sievert (Sv) is the amount of energy absorbed by a kilogram of biological tissue equal in impact to the absorbed dose of gamma radiation of 1 Gy.

While greys measure the radiation absorbed by any material, sieverts measure the radiation absorbed by a person. The relationship between the two is expressed by the formula:

$$1\text{Sv} = 1\text{Gy} * \text{w} \quad (3)$$

where: Sv is the notation for sievert; Gy for grey, and w is a weighting factor specific to a certain type of radiation (wR) and a certain type of tissue (wT).

A simulation was made using the TCL software [28]. The experiment involves searching for a deviation in the specified area with a specified power - the red graph, while the blue graph shows the frequency of the generated RF signal used for irradiation (Fig. 10).

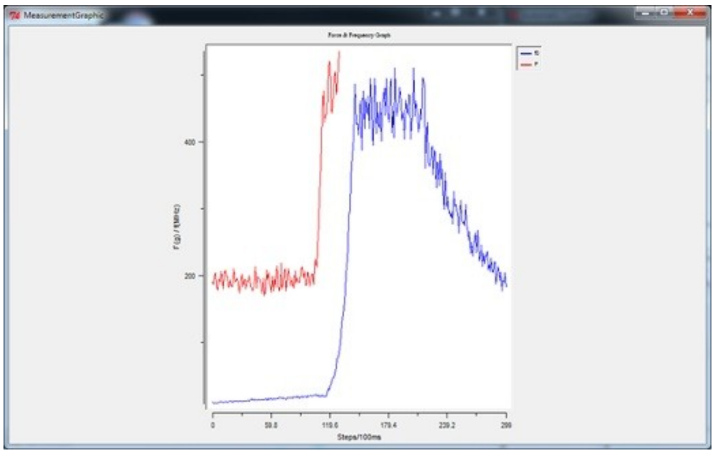

Fig. 10. Local therapy results obtained in simulation.

When the deviation is detected, the formation of microsteps is terminated and the generator starts operating in accordance with the specified program. Upon reaching the specified frequency, in the case of 434 MHz, the irradiation is maintained at the specified frequency and intensity for the time specified by the therapeutic program – In this case 10 seconds. Then the generator is turned off and the frequency drops to a minimum.

For the red graph, the number of microsteps is located on the X axis. The search for the specified power value is shown on the Y axis. For the blue graph, the microsteps of the device are shown on the X axis, and the frequency of the irradiating signal in MHz is shown on the Y axis.

2.3. System for collecting, processing and visualizing data with application in Medicine

Every engineering development also requires appropriate software in order to function properly. The operation and performance of each system and device depends on how it is managed. That is why a system for collecting, processing and visualizing data with application in medicine was designed and developed. We called it Multifunctional Operator Station.

An architecture of a multifunctional, operator control station based on the low-level programming language Tcl/Tk is proposed, consisting of: a communication block, an interface block, a block for additional signal processing, a block for training and simulations, a database, a block with a knowledge base and a graphical interface with video signal capabilities. Of interest are the Expert System block and the training and simulation block.

The architecture of this system can be seen in Figure 11 [29].

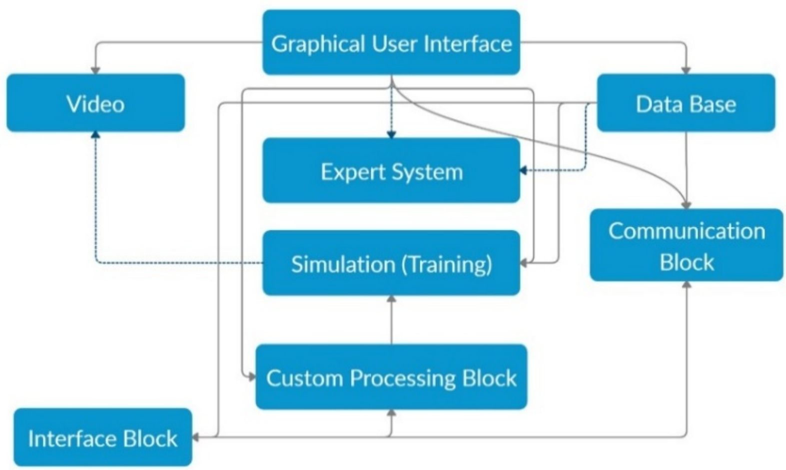

Fig. 11. A Multifunctional operating station.

In the Expert System, part of the software is programmed with the help of artificial intelligence elements. Such systems are used for decision-making and giving advice. They have 2 main components:

- Database with a knowledge base with rules, facts and constraints;
- Interpreter-component for processing signals with a layer of logical functions.

The Expert System interacts with the Graphical User Interface, and all possible solutions are visualized in a meaningful way with the possibility of choice. The control panel of the Multifunctional Operator Station for a robotic system with application in medicine is shown in Figure 12.

On the left side are included radio buttons with the possibility of selection and adjustment, on the right side are the results of the measured values and their presentation in graphical form. As an upgrade to the operator station, a mobile application with Virtual and Augmented Reality capabilities has been developed, the expert system has been replaced with an artificial intelligence block, and the

Graphical User Interface has virtual and augmented reality capabilities. The structure is shown in Figure 13 [30].

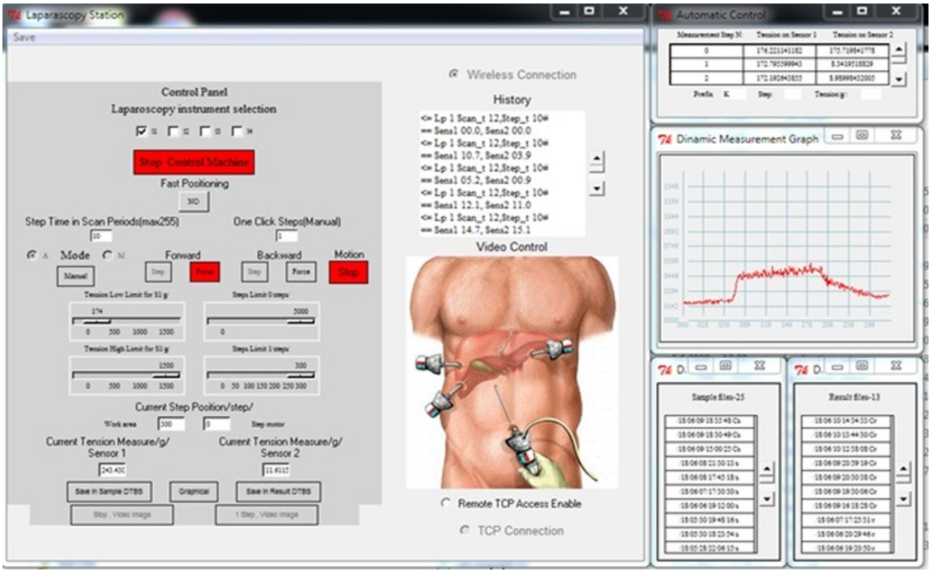

Fig. 12. Control panel of MOS.

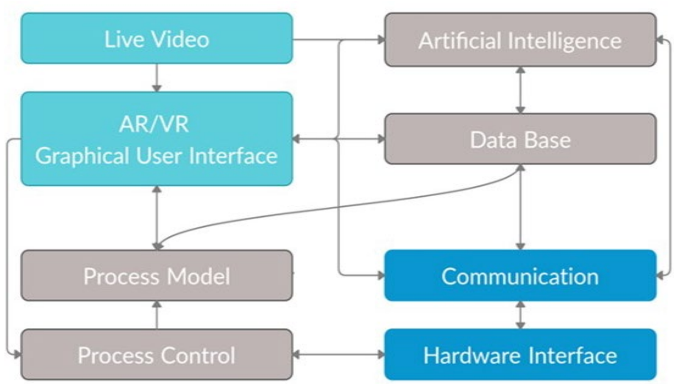

Fig. 13. Mobile application with virtual and augmented reality capabilities.

2.4 The role of robotics in medical education

There is interest in simulation in medical education due to the cost-effectiveness, shortened training period and better outcomes presented after training with simulation. Robotics combined with simulation provides students and future surgeons with an environment close to the real one, where basic knowledge can be acquired and already acquired knowledge can be practiced. A platform for MIS training is proposed – Figure 14, where the monitoring of training includes –

Virtual environment, simulation of the surgical space and surgical skills, robot simulation, force and position feedback, GUI [31].

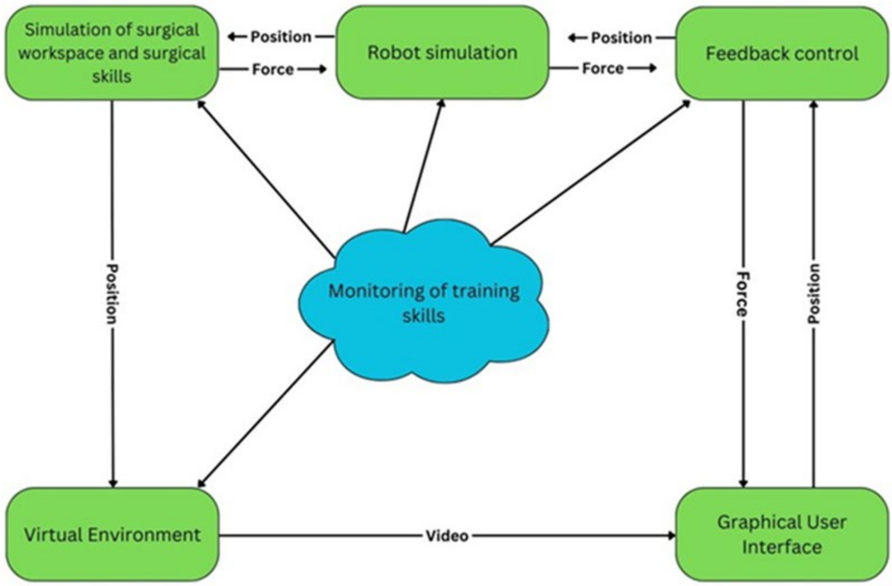

Fig. 14. A Conceptual model of a platform for training skills.

Some of the platform's capabilities are described below, namely:

The surgical workspace and surgical skills simulation block aims to provide visual information added to the working environment during the training of surgical personnel.

The visualization of a specific simulation object is performed after reading the values for the relevant quantities from the laparoscopic instrument sensors upon contact and checking for falling within the set boundaries of the objects.

In the software module, the instruments are simulated, taking into account the kinematic structure and external constraints such as the trocar and the MIS access point. The limits and dynamic behavior of the instruments are simulated with varying levels of reality.

The experimental module of the platform focuses on the specific characteristics and training needs of a newly developed robotic MIS system. The following training skills were identified:

1) The operator connects to the remote platform with radio-controlled buttons when selecting from the Mode (Control Panel) as an alternative to the button of the instrument to which it is connected. The operation of the different instruments is done by selecting in the "Start the control machine", which has an alternative to the buttons of the instruments (F).

2) Workspace limitations of the work console:

The workspace of the input devices is limited. When the operator's movements reach the limits in the desired direction, the instrument is switched off. This command is set in the software automatically. The movements must be repeated to achieve smooth movement.

Workspace limitations: These limitations reduce the workspace and manipulability of the instruments, a situation that the surgeon must be trained to deal with.

Stereo scene visualization: It teaches the operator to get an idea of the distance and positions of instruments and tissues in the displayed scene.

Force feedback: The surgeon learns the sensations with the system during interaction (e.g., learns to replace the sense of touch with the displayed interaction forces). Libraries of 3D organ models have been developed for training during simulation, on which the physical characteristics of real organs are assigned [31].

2.5 Wireless mobile ECG

A conceptual scheme of an ECG device working in saving people in disasters and accidents is shown in Figure 15.

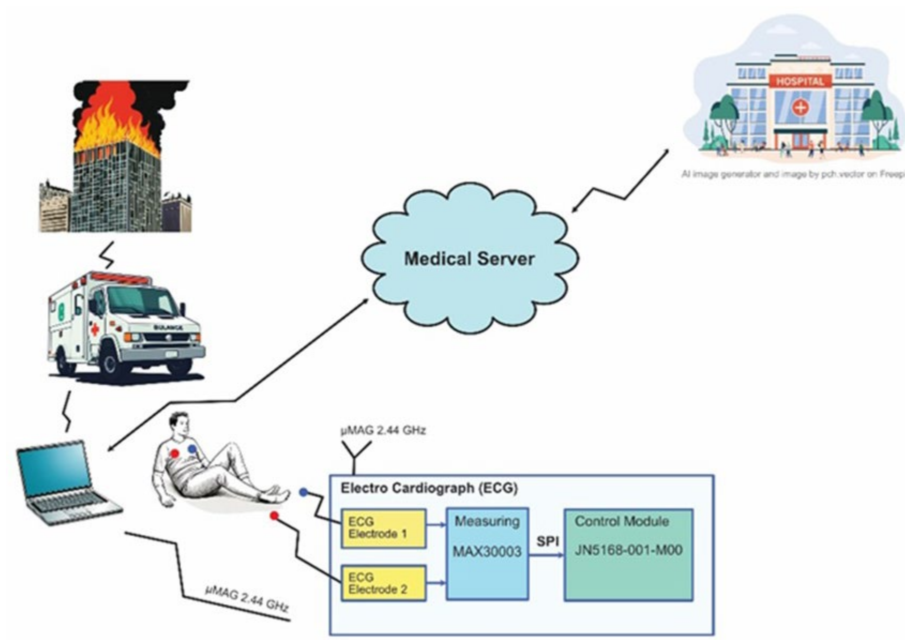

Fig. 15. A Conceptual scheme of ECG device working in saving people in disasters and accidents.

A device measures the electrical potential between 2 points of the human body, generates the electrocardiogram and upon request sends it to a specialized controller. It can work independently or be included in a robotic MIS platform Figure 16. It consists of two modules – measuring and control. The role of the control module is to monitor the operation of the measuring device and to ensure the communication of the device via a wired or wireless interface. The measuring module is based on the Specialized Integrated Circuit MAX30003 (Analog Devices), which is a front-end single-lead ECG chip that has a built-in function for detecting heart rate (R-R detection). suitable for portable applications, which can detect ECG signals of the heart.

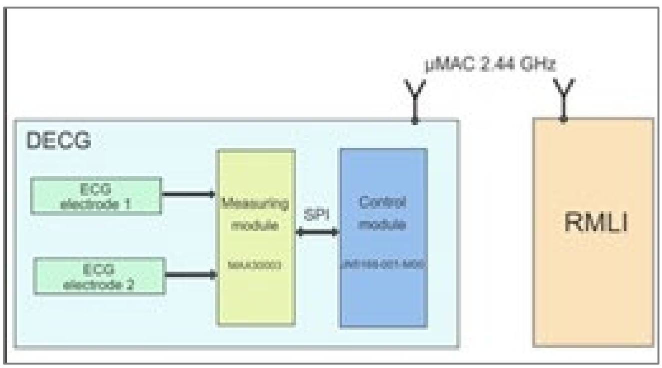

Fig. 16. Communication between control module and robotic tools.

The Specialized Integrated Circuit MAX30003, performing all analog processing of the signals from the electrodes, including collection, filtering, amplification and digital conversion of the microvoltages produced by the heart and supporting an SPI interface with the implemented wireless microcontroller JN5168-001 [32]

3. Directions for future work

The following directions can be highlighted as directions for future work:

1. Complementing the training system with intelligent tools and augmented reality applications for training
2. Additional UML models for training purposes.
3. Simulation software based on AR/VR for training emergency medical personnel to work with an ECG device.
4. Designing a pulse meter, a device for monitoring the level of CO_2 in the abdominal cavity, as well as suitable models of laparoscopic performing instruments and human organs for training purposes.

5. Research on the application of STEMM in the field of minimally invasive surgery.

6. Research in the field of the Internet of Medical Things – IoMT.

4. Conclusion

The modern achievements of Robotics and Mechatronics make them attractive for all areas of human life. Robotic systems also find their place in various branches of medicine. This work examines and proposes innovative solutions based on modern achievements of robotics and mechatronics, providing solutions to a wide range of problems that are applied in various areas of medicine, in response to modern challenges and needs of patients for better healthcare. An overview of the application in various medicine files was presented, as well as authors unique contribution to the discussed topic. Concluding, future directions were introduced that reveal the potential of the presented technologies for further development e.g.in in the field of Internet of Medical Things (IoMT).

References

1. Intuitive Homepage, https://www.intuitive.com/en-us/products-and-services/da-vinci, last accessed 2025/10/20.
2. Medtronic Homepage, https://www.medtronic.com/in-en/index.html, last accessed 2025/10/31.
3. CMR Surgical Homepage, https://cmrsurgical.com/, last accessed 2025/10/20.
4. Asensus Surgical US, Inc. Homepage, https://www.asensus.com/, last accessed 2025/10/20.
5. Stryker Homepage, https://www.stryker.com/in/en/index.html, last accessed 2025/10/20.
6. Edge Medical Homepage, https://en.edgemed.cn/, last accessed 2025/10/20.
7. Benhal, P., Micro/Nanorobotics in In Vitro Fertilization: A paradigm shift in assisted reproductive technologies, Micromachines, vol. 15(4):510, pp. 1-20 (2024) doi: https://doi.org/10.3390/mi15040510.
8. Invenio Blog, The Robotics Industry's response to the AI Revolution, https://invenio.holikstudios.com/technology/the-robotics-industrys-response-to-the-ai-revolution/, last accessed 2025/10/20.
9. RIKEN Homepage, https://www.riken.jp/en/news_pubs/research_news/pr/2015/20150223_2/, last accessed 2025/10/20.
10. BBC News, Homepage, RIP Pepper robot? SoftBank 'pauses' production". 29 June 2021, https://www.bbc.com/news/technology-57651405, last accessed 2025/10/20.
11. Intuition Robotics Inc., Homepage, https://elliq.com/, last accessed 2025/10/20

12. Sensei Robotics, Venture Captial, https://www.senseiroboticsvc.com/, last accessed 2025/10/20.
13. Stereotaxis, Inc., Homepage, https://www.medical-xprt.com/products/robotic-magnetic-navigation-system-792076, last accessed 2025/10/20.
14. Manualzz, Homepage, https://manualzz.com/doc/23746326/stereotaxis-niobe-es-robotic-navigation-system-user-manual, last accessed 2025/10/20.
15. Grischke, J., Johannsmeier, L., Eich, L., Haddadin, S., Dentronics: Review, first concepts and pilot study of a new application domain for collaborative robots in dental assistance. In Proc. of the 2019 International Conference on Robotics and Automation (ICRA), Montreal, QC, Canada, 20–24 May 2019; pp. 6525-6532, doi: 10.1109/ICRA.2019.8794139.
16. Cheema, H.S.; Dhillon, P.K. Robotics in dentistry. Dentimedia: Journal of Dentistry, vol. 17(3), pp. 61-62 (2012).
17. Dhopte A, Bagde H. Cureus, Smart Smile: Revolutionizing dentistry With artificial intelligence, vol. 15(6), e41227, pp. 1-10 (2023) doi: 10.7759/cureus.41227. eCollection
18. ABB Robotics, Homepage, https://library.e.abb.com/public/8aab82f3304248c2b7dc96476c6d4074/ossur_casestudy_en_lr.pdf?x-sign=FJL0lRLR0Sr74OaALt2iTUcNnXQRdSS4al9pBUbrVFu2t5wZzUBI4/nuAdxovNAf, last accessed 2025/10/20.
19. US Department of Veterans Affairs, Homepage, https://www.research.va.gov/research_in_action/The-LUKE-DEKA-advanced-prosthetic-arm.cfm, last accessed 2025/10/20.
20. Open Bionics, Homepage, https://openbionics.com/, last accessed 2025/10/20.
21. Builtin, Homepage, https://builtin.com/articles/lab-on-a-chip, last accessed 2025/10/20.
22. Laerdal Medical, Homepage, https://laerdal.com/SimMan/, last accessed 2025/10/20.
23. Surgical Science, Homepage, https://surgicalscience.com/simulators/lap-mentor/, last accessed 2025/10/20.
24. Singh, A., Editorial Feature How TUG Robots Are Revolutionizing Healthcare Logistics Ankit Singh, 2024, https://www.azorobotics.com/Article.aspx?ArticleID=725, last accessed 2025/10/20.
25. PA, Homepage, https://www.paconsulting.com/client-story/intouch-health-rp-vita-helping-to-make-the-worlds-best-doctors-accessible-everywhere, last accessed 2025/10/20.
26. Ivanova, V., Bachvarov, D., Boneva, A.: A smart laparoscopic instrument with different applications. International Journal of Bioautomation, vol. 24(4), pp. 403-417 (2020) doi: 10.7546/ijba.2020.24.4.000723.

27. Ivanova, V., Boneva, A.: Application of a mechatronic device for local tumor radiotherapy in animal treatment, Problems of Engineering Cybernetics and Robotics, vol. 82, pp. 21-34 (2024) doi: https://doi.org/10.7546/PECR.82.24.02
28. Tcl Developer Xchange, Houmpage, https://www.tcl-lang.org/, last accessed 2025/10/20.
29. Ivanova, V., Boneva, A., Doshev, Y., Ivanov, S., Vassilev, P.: Multifunctional pperating station based on Tcl/Tk and its applications. In: 6th IEEE International Conference "Big Data, Knowledge and Control Systems Engineering" (BdKCSE'2019), pp. 1-7 (2020), doi: 10.1109/BdKCSE48644.2019.9010662.
30. Ivanova, V., Vasilev, P., Stoyanov, I., Andreev, R., Boneva, A.: Design of a multifunctional operating station based on augmented reality (MOSAR), Cybernetics and Information Technologies, vol. 21(1), pp. 119-136 (2021), doi:10.2478/cait-2021-0009.
31. Ivanova, V., Boneva, A., Vasilev, P., Ivanov, S.: A multifunctional training platform for robotic surgery. In: Proceedings on Engineering Sciences (PES), vol. 7(2), pp. 817-828, (2025), doi:10.24874/PES07.02.005.
32. Ivanova, V., Boneva, A. Application of wireless ECG in saving people in disasters and accidents, LNNS, Vol. 883, pp. 410-421, (2024), doi:10.1007/978-3-031-74707-6_43.