HSR (LONDON),
HOUGHTON STREET REVIEW JOURNAL
ISSN: 2058-5519|Impact factor-15.9
http://houghtonstreetreview.com/index.php/hsr

ROBOTICS AND AUTOMATED SYSTEMS IN MEDICINE: TREATMENT METHODS USING AUTONOMOUS DEVICES

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doi:https://doi.org/10.5281/zenodo.23494395

Abstract: The rapid development of robotics, artificial intelligence (AI), and automated technologies is transforming modern healthcare. Medical robotic systems are increasingly used in surgical procedures, rehabilitation, drug delivery, patient monitoring, and minimally invasive interventions. Autonomous and semi-autonomous devices can perform predefined tasks, process real-time information, and support clinical decision-making under specified safety constraints. This article examines the principal applications of medical robotics and automated systems, with particular attention to autonomous treatment technologies. The study reviews robotic-assisted surgery, rehabilitation robots, robotic drug-delivery systems, automated monitoring, and emerging micro- and nanorobotic approaches.
Keywords: medical robotics, automated medical systems, autonomous devices, robotic surgery, artificial intelligence, rehabilitation robotics, drug delivery, patient safety.

Annotatsiya: Robototexnika, sun’iy intellekt va avtomatlashtirilgan texnologiyalarning jadal rivojlanishi zamonaviy sog‘liqni saqlash tizimini o‘zgartirmoqda. Tibbiy robotlashtirilgan tizimlardan jarrohlik amaliyotlari, reabilitatsiya, dori vositalarini yetkazib berish, bemorlarni monitoring qilish va minimal invaziv muolajalarda tobora keng foydalanilmoqda. Avtonom va yarim avtonom qurilmalar belgilangan vazifalarni bajarish, real vaqt rejimida ma’lumotlarni qayta ishlash hamda klinik qarorlarni qabul qilishni qo‘llab-quvvatlash imkoniyatiga ega. Robotlashtirilgan jarrohlik, reabilitatsiya robotlari, dori yetkazib berish tizimlari, avtomatlashtirilgan monitoring hamda mikro- va nanorobototexnikaning istiqbolli yo‘nalishlari ko‘rib chiqiladi.
Kalit so‘zlar: tibbiy robototexnika, avtomatlashtirilgan tibbiy tizimlar, avtonom qurilmalar, robotlashtirilgan jarrohlik, sun’iy intellekt, reabilitatsiya robotlari, dori yetkazib berish, bemor xavfsizligi.

Аннотация: Стремительное развитие робототехники, искусственного интеллекта и автоматизированных технологий трансформирует современную систему здравоохранения. Медицинские роботизированные системы всё шире применяются в хирургии, реабилитации, доставке лекарственных препаратов, мониторинге пациентов и малоинвазивных вмешательствах. Автономные и полуавтономные устройства способны выполнять заранее определённые задачи, обрабатывать информацию в режиме реального времени и поддерживать

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принятие клинических решений в установленных пределах безопасности. Анализируются робот-ассистированная хирургия, реабилитационные роботы, системы доставки лекарственных препаратов, автоматизированный мониторинг, а также перспективы микро- и наноробототехники.

Ключевые слова: медицинская робототехника, автоматизированные медицинские системы, автономные устройства, роботизированная хирургия, искусственный интеллект, реабилитационные роботы, доставка лекарственных препаратов, безопасность пациентов.

Introduction: The integration of robotics and automated systems into medicine represents an important stage in the development of modern healthcare. Advances in mechanical engineering, computer vision, sensor technology, artificial intelligence, and real-time data processing have enabled medical devices to perform increasingly complex tasks. These technologies are being introduced to support healthcare professionals, improve procedural precision, and provide new approaches to diagnosis, treatment, and rehabilitation. Traditional medical procedures frequently depend on the experience, physical capabilities, and manual precision of healthcare professionals. Although clinical expertise remains indispensable, certain tasks may benefit from robotic assistance, standardized automation, and continuous monitoring.

Materials and Methods: This article uses a narrative review approach based on published scientific literature and authoritative regulatory and international guidance. The analysis draws on research concerning healthcare robotics, autonomous surgical systems, and the ethical governance of artificial intelligence in medicine. Relevant sources were selected to identify major application areas, technological capabilities, clinical limitations, and safety considerations.

Robotic-Assisted Surgery: Robotic-assisted surgery is one of the most established applications of robotics in healthcare. These systems typically combine a surgeon-operated console, robotic arms, surgical instruments, imaging equipment, and computer software. They translate the surgeon's movements into controlled instrument movements and may provide magnified three-dimensional visualization.

Rehabilitation and Assistive Robotics: Rehabilitation robotics supports patients recovering from stroke, spinal cord injury, neurological disorders, and musculoskeletal conditions. These systems include robotic exoskeletons, upper- and lower-limb rehabilitation devices, robotic gait trainers, and interactive therapeutic platforms.

Automated Drug Delivery and Treatment Systems: Automated treatment systems are designed to deliver medication or regulate therapeutic parameters according to programmed instructions and, in some cases, real-time measurements. Examples include programmable infusion pumps, automated insulin-delivery systems, and closed-loop devices that combine sensors, control algorithms, and medication delivery mechanisms. In a closed-loop system, sensor data are processed by a controller that adjusts treatment within predefined limits.

Future Perspectives: The future of medical robotics is likely to involve closer integration of AI, advanced sensors, medical imaging, digital twins, and personalized treatment planning. These technologies may enable systems to interpret complex information, adapt selected functions to changing conditions, and support clinicians during more sophisticated procedures. One promising direction is the development of collaborative robots that work alongside medical professionals. Rather

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than independently replacing clinicians, these systems may provide precision assistance, automated measurements, and real-time feedback.

Conclusion: Robotics and automated systems are becoming important components of modern medicine. Their applications range from surgeon-controlled robotic instruments and rehabilitation devices to automated medication delivery, continuous patient monitoring, and experimental targeted-treatment technologies. By combining mechanical precision, sensor-based feedback, and computational analysis, these systems can support selected clinical tasks and contribute to more consistent and individualized care. Nevertheless, the benefits of medical robotics depend on appropriate clinical selection, reliable engineering, adequate training, regulatory compliance, and continuous evaluation. Autonomous capability should be introduced gradually and proportionately to the risks of the medical task. Systems that perform high-risk interventions require particularly strong safeguards and clearly defined human oversight.

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