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AI-Driven Robotic Arm for Medical Surgeries

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Abstract: Artificial intelligence (AI) applications in medical robotics are ushering in a new epoch in medicine. Advanced medical robots are capable of executing diagnostic and surgical operations, facilitating rehabilitation, and offering symbiotic prostheses to substitute missing limbs. The technology used in these devices, including computer vision, medical image analysis, haptics, navigation, precise manipulation, and machine learning (ML), may enable autonomous robots to do diagnostic imaging, remote surgery, surgical subtasks, or whole surgical operations. Furthermore, artificial intelligence in rehabilitation devices and sophisticated prostheses may provide personalized assistance, along with enhanced functioning and mobility (refer to the image). The amalgamation of remarkable advancements in robotics, medicine, materials science, and computers may yield safer, more efficient, and more accessible patient care in the future.

Keywords: *materials science, remarkable****,*** *operations*

Introduction

With each successive advancement, artificial intelligence has shown its use in assisting the healthcare system. Public and commercial hospitals are enhancing their offerings via adoption. many technologies, including wearables, 3D printing, virtual reality (VR), and surgical robots, including others. The first surgical robot was used for arthroplasty in 1983 in Canada (Rubin, 2017). Currently, some of the most renowned surgical systems are da Vinci (for a variety of surgeries) and Ion. for lung biopsies, Mako for hip and knee arthroplasty, NAVIO for knee procedures replacement surgery and Monarch for bronchoscopies, among others (Carfagno, 2019). Robotic surgery might be seen as an independent system doing the procedure. In the absence of human interaction, this does not apply to most systems. Rather, the majority of surgical procedures Robots are now aiding a qualified surgeon throughout the operation. This entails benefits. Include enhanced accuracy and stability, reduced trauma, three-dimensional visualization with magnification, and automation. Multitasking and its drawbacks, including elevated installation and maintenance expenses. diverse developmental trajectories, potential for dysfunction, challenges in establishing patient trust and others (Soomro et al., 2020; Pitcher et al., 2012; Nichols, 2019; Pandey & Sharma, 2019). As technology advances and the need for robotic surgery rises, the impetus in

Competition is enhancing quality while reducing implementation costs (Perez & Schwaitzberg, 2019. The pace of advancement in robotic surgery may not align with a comparable expansion in public awareness and confidence.

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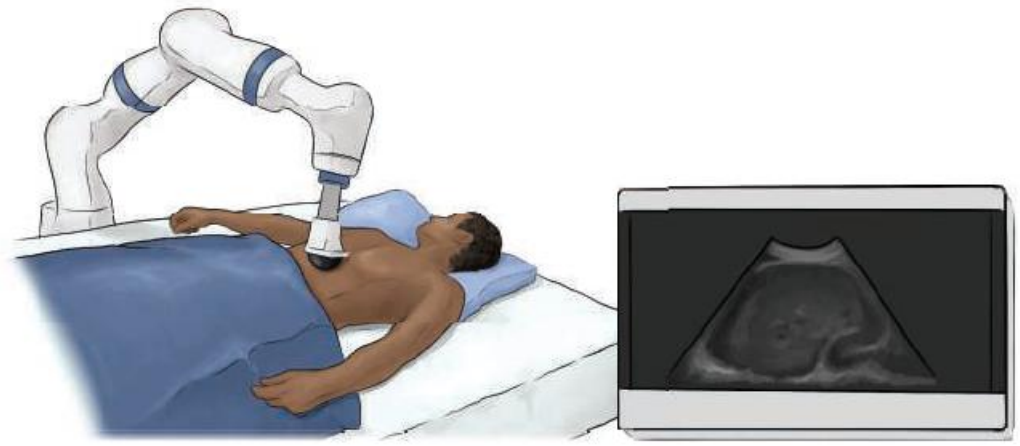

Figure 1: Robotic Arm For Medical Surgeries

Medical image-guided robotics integrates medical imaging, which identifies critical anatomical structures, lesions, and objects, with robots, enabling the precise positioning of devices or equipment, hence offering significant benefits. Commonly used imaging methods include ultrasound, magnetic resonance imaging, computed tomography, and white-light or fluorescent endoscopy.

The robot may help in anatomical imaging, or the imaging may aid the robot in directing it to critical objectives.

Numerous first applications of AI in medical image-guided robotics included maneuvering tools, mostly needles, to locate anatomy for biopsies. The emphasis of the AI was mostly on steering mechanics and planning algorithms, since navigating soft tissue necessitated curved trajectories limited by the minimum radius of curvature inside the tissue, with tissue displacements after instrument implantation. Despite ongoing challenges in navigating minimally invasive robotic tools that engage with tissue intermittently, a wide array of AI-driven solutions for robotic instrument steering is now accessible, and advanced dexterous robotic systems capable of planning and achieving targets with AI assistance have been proposed.

The majority of current efforts focus on visual comprehension. Prior methodologies used laborious, manually segmented (hand-annotated) anatomical characteristics and/or feeble, feature-based identification of the anatomy of interest. Novel AI methodologies for image guiding use semantic information—specifically, advanced reasoning over anatomical types and their attributes, derived directly from pixel data, to enhance navigation safety and efficacy. Significant advancements in object localization and scene segmentation within computer vision have begun their application to surgical environments and pertinent surgical items.

Background

Artificial intelligence (AI) integrates many technologies, enabling software robots to emulate human intellect. It employs a cross-disciplinary methodology including computer science, mathematics, neurology, and more domains, allowing robots to see, learn, reason, act, and enhance their performance via feedback. The projected global market size for AI in healthcare in 2021 was USD 10.4 billion, anticipated to attain USD 120.2 billion by 2028, with a compound annual growth rate (CAGR) of 41.8%, encompassing software, hardware, and service solutions (Grand View Research, 2021).

In 2020, the application of AI in healthcare was predominantly observed in clinical trial design, succeeded by robot-assisted surgery, as manufacturers of surgical robots began forming strategic alliances with AI technology providers and data analytics firms. This trend is projected to continue growing by 2028, driven by an increase in smartphone and AI utilization among patients and medical professionals. The main entities in artificial intelligence for healthcare are IBM, NVIDIA, Nuance Communications, Microsoft, Intel, and DeepMind (Grand View Research, 2021).

Nonetheless, the use of AI in healthcare is seen with apprehension over the potential for robots to entirely supplant physicians (Shuaib et al., 2020). According to PwC (2018), the healthcare industry will need more use of AI and robots, in conjunction with a larger workforce, since it is one of the sectors with limited automation possibilities over the next two decades. Furthermore, the study indicates that individuals are receptive to the integration of AI and robotics in surgical procedures and other healthcare domains.

The conventional methods in healthcare are revolutionized with the use of AI (Bellini &. The use of predictive analytics in surgery is deficient in both depth and adaptability compared to AI (Loftus et al., 2020). Disciplines of artificial intelligence, including natural language processing (NLP), machine learning (ML), and deep learning (DL), when integrated with big data, possess the capacity to enhance decision-making processes before and after surgical procedures (Loftus et al., 2020). This is particularly relevant given that various studies indicate that medical professionals and trainees exhibit deficiencies in statistical literacy regarding the interpretation of p-values, relative risks, and odds ratios (Schmidt et al., 2021; Anderson et al., 2013; Petrova et al., 2019; Krouss et al., 2016).

The medical field derives numerous advantages from AI, including the reduction of diagnostic errors (Ehteshami Bejnordi et al., 2017), assistance in drug development (Fleming, 2018), enhancement of hospital efficiency (Anagnoste et al., 2021; Sennaar, 2020), and improvement of surgical precision and outcomes (Edwards et al., 2018).

In ophthalmology, machine learning may enhance diagnostic accuracy for certain diseases and improve screening for glaucoma, cataracts, macular degeneration, and diabetic retinopathy (Jayadev & Shetty, 2020). Artificial intelligence forecasts with over 93% accuracy the patients who will gain from laser refractive operations, including laser-assisted subepithelial keratectomy (LASEK) and tiny incision lenticule extraction (SMILE) (Jayadev & Shetty, 2020). Additionally, AI can forecast the likelihood of surgical problems associated with laser-assisted in-situ keratomileusis (LASIK), including postsurgical ectasia (Ting et al., as referenced in Jayadev & Shetty, 2020).

Nonetheless, the pace of advancement in robotic surgery may not align with a corresponding increase in public knowledge and confidence. Numerous studies regarding public perception of robotic surgery have determined that there are misconceptions and a limited comprehension of the technology and its advantages. It is essential for healthcare providers to elucidate the AI procedures while being cognizant of the misinformation that patients may have encountered (Stai et al., 2020; Boys et al., 2016; Buabbas et al., 2020). A research analyzing social media data revealed that public view of AI in healthcare is mostly favorable; nonetheless, people see it as unapproachable, urging medical professionals (Geo et al., 2020).

Research Aims And Methods

The paper seeks to evaluate contemporary public opinion regarding robotic eye surgery (RES), thereby enhancing the literature on public perception of robotic surgery. The investigation centers on Romanian citizens and addresses the research question: How is RES perceived by the public regarding: (1) safety (in comparison to traditional procedures conducted solely by surgeons), (2) anticipated price trends in subsequent years, and (3) technology as a transformative force in the medical domain; while accounting for demographic variables such as gender, age, education level, income level, presence of visual impairments, and the intention to wear glasses.

An online self-administered poll was conducted among random Romanian residents in 2021, yielding 137 valid responses. The sample size satisfies the criteria for a 95% confidence level with an 8.4% margin of error. The survey has two components. The first component seeks to collect demographic information, including gender, age, location, education, income, presence of visual impairments, and the desire to wear glasses. The second component has 24 questions, each assessed using a 6-point Likert scale to examine public opinion on various elements of renewable energy sources (RES).

The poll was examined using SPSS using exploratory factor analysis (EFA) on the Likert questions, a chi-square test to assess the correlation between those reporting vision problems and their desire to wear glasses, and one-sample t-tests to evaluate public consensus on the assertions. Index variables were generated by calculating the arithmetic mean of the observed variables for each of the three indicated components. A stepwise regression model was developed to assess the influence of two index variables (namely, the perceived degree of optimism on the price development of renewable energy sources in the next years) on a third variable (specifically, the level of trust in renewable energy sources).

Artificial intelligence facilitates symbiotic robotic prosthetics. Authored by He (Helen) Huang and I-Chieh Lee

Advanced robotic prostheses, including dexterous prosthetic hands and motorized prosthetic legs, have initiated a paradigm change in restoring movement for persons with limb loss. Contemporary prostheses include artificial intelligence into their functionality to facilitate adaptability to user intent, environmental conditions, and the user's physical state. This is crucial for human-prosthesis symbiosis—an intelligent prosthesis and a human user operating cohesively as a unified system in everyday life (53).

For instance, artificial intelligence has facilitated brain regulation of prosthetic extremities. The thought of controlling prosthetic limbs based on human desire from the brain is intriguing. This necessitates a proficient neural decoder capable of precisely interpreting user intent via human neuromuscular signals for prosthetic limb control. Machine learning algorithms, encompassing basic linear classifiers to advanced deep learning regression models, serve as effective neural decoding techniques for identifying user intent related to joint movements (e.g., wrist or knee flexion and extension), hand grasping patterns (e.g., fine pinch or power grip), or modes of locomotion (e.g., sit-to-stand transitions and level ground walking) (54, 55). The output from the ML decoder is sent to the prosthesis controller to generate the user's desired limb movement, facilitating human-prosthesis symbiosis during task execution.

The integration of AI in human-prosthesis symbiosis facilitates adaptability to diverse surroundings and circumstances. Human hands can skillfully manipulate things of many sizes and materials; human legs can adjust to varied terrains while ambulating.

Consequently, a symbiotic prosthetic limb must likewise be ecologically adaptable. Machine vision has been utilized to enhance environmental awareness for prosthetic control. Utilizing deep learning algorithms on images obtained from cameras affixed to a prosthetic hand, machine vision can identify the target object for grasping, enabling the prosthetic arm to adjust the wrist position and hand grip pattern or force to assist in grasping actions. Likewise, vision sensors affixed to prosthetic legs can identify the terrain ahead of the user, therefore automatically adjusting prosthesis control for smooth transitions over different surfaces.

A symbiotic prosthesis must provide tailored support to each user due to significant variations in physical circumstances and motor limitations across amputees. In contemporary clinics, the customization of robotic lower-limb prosthetic control is executed manually and heuristically, resulting in inaccuracies and requiring significant time and effort. Researchers have created reinforcement learning algorithms and other data-driven optimization methods, including Bayesian optimization, to automate the tuning of prosthesis control with human involvement for customized walking aid. In reinforcement learning-based algorithms, the prosthesis personalization process can be completed in as little as five minutes, and the resulting intelligent AI tuning agent can maintain user-adaptive control across various time intervals. Despite the significant potential of AI in robotic prosthetics, it must be enhanced for greater robustness and safety in daily prosthesis operation due to the involvement of human operators. Furthermore, it remains an unresolved inquiry if human users cognitively integrate and place faith in AI-enhanced prosthetics. These problems should guide future research initiatives to develop AI-enabled symbiotic robotic prostheses that are adaptable, safe for use, and cognitively acceptable to individuals with limb amputations.

CONCLUSION

Comprehending the current perspective on robotic surgery is essential for formulating assistance initiatives.

The findings indicate that RES is seen as a more secure option compared to conventional surgical treatments conducted only by surgeons, and the anticipated price trajectory of RES for the next years is viewed with moderate optimism. Technology is seen as a catalyst for transformation in the medical sector. Furthermore, the respondents acknowledge the advantages of renewable energy sources, particularly in facilitating the integration of artificial intelligence in medicine via the provision of subsidies.

The income level has no significant correlation with the degree of optimism about the future price trends of renewable energy sources. It maintains a slight positive association with the amount of faith in renewable energy sources (RES).

The gender, age, educational attainment, presence of

visual impairments, intention to utilize medical services, degree of trust in renewable energy sources (RES), and level of optimism concerning the future price trends of RES.
The effect exerted on the medical sector and the degree of hope about the price trajectory of RES in the next years significantly contribute to predicting the level of confidence in RES.
The paper is subject to some constraints. The poll lacked definitions of robotic eye surgery and the use of artificial intelligence in medicine, potentially resulting in measurement inaccuracies. Secondly, the survey examined general vision concerns, if any, by RES or other methods. Finally, the absence of participants above 55 years old constrains the representation of perspectives from those susceptible to prevalent age-related ocular issues. Subsequent research may concentrate on particular medical conditions regarding their treatment and management via AI technology, or adopt a qualitative methodology, examining AI in healthcare from both the medical and technological development perspectives.

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