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Advancements in Tele Operated Robotics for Minimally Invasive Surgical Procedure

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Abstract: The many aspects of robotic-assisted minimally invasive surgery (RAMIS) and associated technologies are examined in this thorough overview of the literature. The works that are emphasised explore the developments and difficulties in this subject, which has a wide range of applications from neurovascular treatments to orthopaedic surgery. Examining topics such as recording femur motions, remote sensing in agriculture, and the effect of direct-to-consumer advertising on patient outcomes in robotic coronary artery bypass grafting, the changing environment of RAMIS is discussed. Technology is explored how robotic surgery is becoming more and more common, with a focus on how it is spreading to various operations despite the scant proof of its clinical benefits. The advantages and disadvantages of RAMIS are discussed, including lower hospital stays and scarring but also higher expenses and more complicated technological requirements. In addition, methods for validating multi-robot surgery platforms are examined, as is the possibility of using soft surgical robots to improve minimally invasive surgery. Specific applications including esophagectomy, semantic segmentation on surgical equipment, and RAMIS utilisation in head and neck surgery are also covered in the paper. Present topics include the difficulties in delivering haptic feedback, insights into intelligent surgical robots, and the use of data and artificial intelligence to improve surgical performance. Topics covered include the viability of virtual surgical mentorship, the design and assessment of user interfaces for teleoperated surgical robotic systems, Regarding the outcomes of colorectal cancer surgery using robotics and laparoscopy. A thorough summary of the state of RAMIS today, as well as its obstacles and prospects, is given in this synthesis, which will be of great use to scholars, medical professionals, and other interested parties in the rapidly changing field of MIS.

Keywords Robotic-assisted minimally invasive surgery, surgical robotics, haptic feedback challenges, artificial intelligence in surgery, multi-robot platforms. .

1. Introduction

This is a comprehensive assemblage of study summaries that provides a summary of the situation as of affairs and potential directions for (RAMIS) and associated technologies. The varied research covers a wide range of surgical applications, including colorectal cancer resections, orthopedic operations, neurovascular surgeries, and agricultural remote sensing. The investigation of novel orthopedic surgery systems that use ultrasound pictures to monitor and adjust for femur movements is a prime example of the most advanced developments when registering images and processing methods that do away with the requirement for implanted fiducial markers. The review explores RAMIS's broader implications beyond surgical applications, looking at how it affects patient recruitment, satisfaction, and clinical outcomes in heart surgery. Robotic surgery is being used more and more, but there is no proof of its clinical benefits. This makes it crucial to monitor its spread and make sure it is used wisely in the best possible clinical settings. The complex conversation also covers the advantages and disadvantages of RAMIS, ranging from less pain and scarring to higher expenses and technological difficulties, which calls for more excellent research to fully assess long-term results and patient happiness.

The review broadens its scope to include technological developments that are aimed at improving the safety and efficacy of minimally invasive surgery, such as multi-robot surgery platforms and the exciting developments in soft surgical robots. It also examines cutting-edge technologies, such as data and artificial intelligence (AI) in RAMIS, highlighting how they might improve surgical performance, safety, and results in the modern data era. Reflecting the breadth and depth of research in this dynamic subject, the extensive coverage includes intelligent surgical robots, soft robotic devices, flexible endoscopes, and sophisticated techniques in semantic segmentation and domain adaption.

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2. Literature Review

A method for robot-assisted orthopaedic surgery that uses ultrasound pictures to track and provide a method to compensate for femur movements during bone drilling techniques by **P.M.B. Torres et al. (2019)**. The technology uses image processing and registration techniques to align the intraoperative ultrasonic point cloud of the femur with the preoperative CT model, instead of requiring any fiducial markers to be placed in the bone.

A thorough analysis of the state of remote sensing applications in agriculture today and their predictions for the future was provided by **Julian Klodmann et al.(2021)**. It discusses the potential of remote sensing to address numerous agricultural difficulties and covers a range of remote sensing-related topics, including data collecting, processing, and analysis.

Soroosh Kiani et al. (2023) examined (DTCA) campaign on patient recruitment, satisfaction, clinical outcomes, and patient characteristics, expectations, and outcomes regarding robotic coronary artery bypass grafting (rCABG), a cutting-edge, less invasive technique in heart surgery.

The surgical community should keep an eye on the spread of robotic surgery and make sure that it is applied in the most beneficial clinical contexts. **Kyle**
H. Sheetz et al. (2019) talked about how the usage of robotic surgery has grown significantly and spread widely across several treatments, even in the face of scant data and ambiguous therapeutic significance. Additionally, they discovered a correlation between the adoption of robotic surgery and a decline in open and laparoscopic procedures.

According to **Andreas Meinzer et al. (2020)**, there are advantages and disadvantages to consider, including decreased pain, scarring, and hospital stays as well as higher expenses, technical challenges, and possible complications. Additional high-quality research and hard data are required to assess the long-term results, cost-effectiveness, and patient satisfaction of in children.
Alberto Sanna et al. (2020) covered the technical and functional performances of the SARAS MRS platform with system, as well as the validation protocol and outcomes of the multirobots surgery (MRS) platform, which attempts to automate the assistive tasks during robotic assisted minimally invasive surgeries (R-MIS).

According to **Han Ding et al. (2021)**, soft surgical robots have made significant strides and are expected to improve the efficacy and safety of minimally invasive surgery (MIS). The authors also discussed the desired features of next-generation MIS from the standpoint of surgeons, including smaller incisions, improved adaptability, and more user-friendly manipulation, engineering design, and fabrication techniques.

The present literature on robotic-assisted minimally invasive esophagectomy (RAMIE) was explained by **Frank J. Voskens et al. (2019)**, who also gave an outline of anticipated future advancements in robotic surgery. Developed during the past 15 years, RAMIE is a minimally invasive method that has demonstrated greater quality of life and peri-operative morbidity when compared to open esophagectomy.

Florian Fröhlich et al. (2020) presented the use of domain-adapted training data to improve semantic segmentation using devices for minimally invasive surgery. They also covered the Cycle GAN model, which is used to transform artificial data into data that appears realistic which is used to train U-Net, a semantic segmentation neural network.

In their investigation of robot-assisted minimally invasive surgery (RAMIS), **Tamás Haidegger et al. (2022)** focused on the data and artificial intelligence (AI) landscape and how it can improve surgical performance, safety, and outcomes. They also discussed the challenges and opportunities for RAMIS in the era of data.

Tamás Haidegger et al. (2022) examined the most advanced and developing technologies in (RAMIS), emphasizing the contribution of data and artificial intelligence (AI) to improved surgical outcomes, safety, and performance, as well as the difficulties and potential paths for RAMIS in the data era.

The current state of soft robots for (MIS), including endoscopy, laparoscopy, and catheterization, was described by **George P. Mylonas et al. (2018)**. The authors also compared the devices based on their functions, materials, manufacturing processes, actuation, locomotion, sensing, and performance, as well as the opportunities and challenges associated with developing and manufacturing soft robots for MIS applications.

Manish Kumar Goyal et al. (2023) examined flexible endoscopes, which have the potential to perform minimally invasive surgery while improving safety and requiring less space. They also examined the endoscope's design, vision feedback, and control mechanisms, assessing its ability to track surgical instruments, comparing it to rigid endoscopes, and reporting on user satisfaction and experience.

Based on published and ongoing trials, **Jens Greve et al. (2021)** examined the use and promise of (RAS) in surgery. They also reviewed the costs, safety, and clinical effectiveness of RAS in various

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anatomical locations and compared it with traditional approaches. Future directions and problems were also covered.

The history, evolution, and uses of surgical robotics were covered by **Oguz Borat et al. (2021)**, along with the opportunities and problems that this subject presents, the advantages of different robotic systems and businesses, market trends, and growth prospects. The effects of robotic surgery on the environment and on medicine were also covered.

The design, modelling, control, and sensing of flexible manipulators, as well as the opportunities and challenges in this field, were all covered by **Michel De Mathelin et al. (2022)** in their explanation of the major technological issues and recent advancements in flexible surgical robots for endoluminal surgeries, which are minimally invasive procedures carried out through natural orifices or small incisions.

James Davies et.al (2023) provided an explanation of the design and assessment of user interfaces for teleoperated surgical robotic systems, which facilitate remote and minimally invasive surgery. They also covered the challenges and future directions in this field, as well as the visualisation, haptics, ergonomics, and usability of various interface modalities, including joysticks, master manipulators, and virtual reality.

The challenges and solutions for providing haptic feedback in teleoperated surgical robotics were covered by **Rajni V. Patel et al. (2022)**. This can improve the surgeon's sensory awareness, accuracy, and control over haptic interfaces. Other topics covered included the effects of communication delays and stability, as well as techniques for sensory substitution and augmentation.

The viability of virtual surgical instruments—a means of transmitting information from a mentor to a mentee—across the internet was examined by **Dehlela Shabir et al.** in 2022. Real-time communication between the two surgeons is made possible by the overlay of their motion onto the live picture of the operating field.

A telerobotic platform for magnetic manipulation-based neurovascular therapies was presented by **Aman B. Patel et al. (2019)**. It covered the difficulties in stroke care and endovascular neurosurgery and included a magnetic guidewire that is remotely maneuvered by a robot arm with an actuator magnet installed.

The benefits of minimally invasive surgery (MIS) for patients and surgeons, including decreased trauma, quicker recovery, better outcomes, and enhanced performance, were also covered by **Michele Tonutti et al. (2017)**. They also outlined the latest advancements in cameras, instruments, robotics, and imaging for MIS, as well as the current challenges and future directions in the field.

According to **Sen Li et al. (2023)**, there is no discernible difference in the pathological, postoperative, or survival outcomes between robotic and patients with colon cancer undergoing laparoscopic surgery 80 years old or older. Additionally, the use of robotic surgery is linked to a lower intraoperative blood loss, particularly in patients with anemia.

Aldo Rocca et al. (2021) reported a technically feasible method with low rates of conversion, complications, and mortality for concurrent robotic removal of colon metastases from liver cancer in 28 patients. The trocar implantation, docking, and resection techniques for various liver and colorectal segments, as well as the median surgical time and length of hospital stay, are all appropriate. Each specimen is taken out individually.

Using optical flow features and a variety of classification techniques, **Gábor Lajkó et al. (2021)** investigated a 2D image-based method to assess surgical skills in (RAMIS). They also compared the performance of extraction and classification methods and reported the highest accuracy for each surgical task.

In their article from 2022, **Tamás Haidegger et al.** addressed the use of data science techniques to evaluate and enhance non-technical skills in minimally invasive surgery (MIS), such as situation awareness, stress management, and decision-making. They also presented a MIS training experiment that uses a sensitized phantom to simulate a laparoscopic cholecystectomy task, and measures the participants' workload and non-technical skills using a self-rating questionnaire and sensory data (video and force).

3. Result and Discussion

Robotic-assisted orthopaedic surgery has made strides in the last few years, especially in controlling femur movements during bone drilling operations without implanted fiducial markers. The suggested method does not require intrusive markers because it tracks and compensates in real-time using ultrasound pictures. This technology, which shows promise for improved surgical precision, uses image processing and enrolment for intraoperative alignment ultrasound Femur point clouds using pre-operative CT models. Furthermore, a thorough analysis of remote sensing applications in agriculture highlights how this technology can be used to overcome a range of agricultural difficulties. Review topics include data collection, processing, and analysis,

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with a focus on how remote sensing might help with pressing problems in the agricultural sector.

This study examines the direct-to-consumer advertising's effects on patients recruitment, satisfaction, and clinical results related to robotic coronary artery bypass grafting (rCABG). The study explores the traits, anticipations, and results of patients having this innovative, minimally invasive heart surgery. Additionally, the broad use of robotic surgery in a variety of operations is explored, emphasizing the difficulties that come with it as well as the significance of keeping an eye on its efficient use in the surgical community. The study calls into question the clinical benefits and available data to justify the growing use of robotic surgery, especially when compared to more conventional laparoscopic and open surgical techniques.

4. Conclusion

In summary, the wide spectrum of research that has been given demonstrates how robotically assisted and minimally invasive surgery is an area that is always evolving and improving. An encouraging path for increased accuracy in bone drilling operations is the creation of a robot-assisted orthopaedic surgery system that can follow and adjust for femur motions without the use of implanted fiducial markers. As covered in a thorough overview, remote sensing applications in agriculture highlight how technology may be used to address issues in agriculture by taking care of things like data collection, processing, and analysis. In the meantime, the effect of direct-to-consumer robotic coronary artery bypass grafting highlights the importance of comprehending patient acquisition, happiness, and clinical results for innovative cardiac surgery methods. As the studies have shown, there is a growing trend toward robotic surgery despite the paucity of evidence and uncertain clinical benefits. This emphasises the need for continuous monitoring to guarantee optimal use in the most suitable clinical settings. Furthermore, talks on the advantages and difficulties of different robotic platforms—like multi-robot systems and intelligent surgical robots—help us better comprehend the wide range of robotic applications. Developments in flexible endoscopes and soft surgical robots demonstrate a move in the direction of improving minimally invasive surgery safety and versatility.

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