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Autonomous Robotic System For Surgery Assistance

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Abstract
Combining robotic devices with different degrees of autonomy to carry out surgical procedures is the focus of the fascinating and cutting-edge field of autonomous robotic surgery. The continuous incorporation of machine learning (ML) and artificial intelligence (AI) into surgical procedures has enabled this dramatic change. Some autonomous robotic systems have successfully entered clinical use, while the majority are still in the experimental stage. This historical journey highlights how gradually autonomous systems have been woven into surgical practices. Beginning with the fundamental ideas and progressing through significant turning points in the development of robotic surgery, this review will explore many facets of autonomous robotic surgery and show how autonomous systems have been adopted gradually. In addition, the main advantages and disadvantages of this technology will be covered, as well as the different levels of autonomy that surgical robots possess, their limitations, the regulations currently governing their use, and the primary ethical concerns surrounding them.
Keywords: *clinical applications, ethical concerns, legal regulations, artificial intelligence*

INTRODUCTION

The goal of the fascinating and cutting-edge field of autonomous robotic surgery is to remove the surgeon's hands from the equation. The goal of this technology is to develop robotic systems that are remarkably independent in performing surgical procedures. Surgical robots with autonomous control may be more accurate, maneuver more intelligently, and cause less tissue damage [1]. While the bulk of these robotic devices are still in the experimental stage, several have already started to be used in clinical settings. Researchers are working diligently to create fully autonomous surgical tools that can perform intricate procedures on malleable, soft tissues, such intestinal suturing and anastomosis, in open surgical settings. Preliminary studies suggest that supervised autonomous therapies could even be more reliable and successful than robot-assisted procedures and well done surgery[2]. These developments in autonomous robotic surgery have enormous potential to improve surgical results and make cutting-edge methods more widely available [9]. From video games and automated public transportation to personal assistants like Siri, Alexa, and Google Assistant, as well as the aviation industry, artificial intelligence has a significant impact on many aspects of our everyday life. Surgeons doing robotic surgery can see the operative scene on a screen as 2D projections that were recorded by the endoscope [3]. To understand the surgeons' intent, the witnessed demonstration must be monitored and examined. This can be accomplished by recording the surgeons' instruments movements during an intervention. This is achieved by first detecting surgical tools in numerous portions (segmenting surgical instruments in each subsequent frame for a full surgical video) and then tracking particular places on the instrument as the procedure is being performed.

REVIEW OF LITERATURE

In recent years, the medical community has come to accept robot-assisted minimally invasive surgery (MIS) more and more. In robot-assisted surgery, the treatments are carried out through tiny incisions and the surgeons are given sophisticated control and clever tools[4]. Surgeons can treat each patient more safely thanks to the specific instruments and laparoscope/endoscope found in these surgical systems. Because the surgeon collaborates with robotic equipment, an intraoperative human-machine interface is required. The intra-operative assistance system helps the pros during surgery and trains the aspiring surgeons. [13].

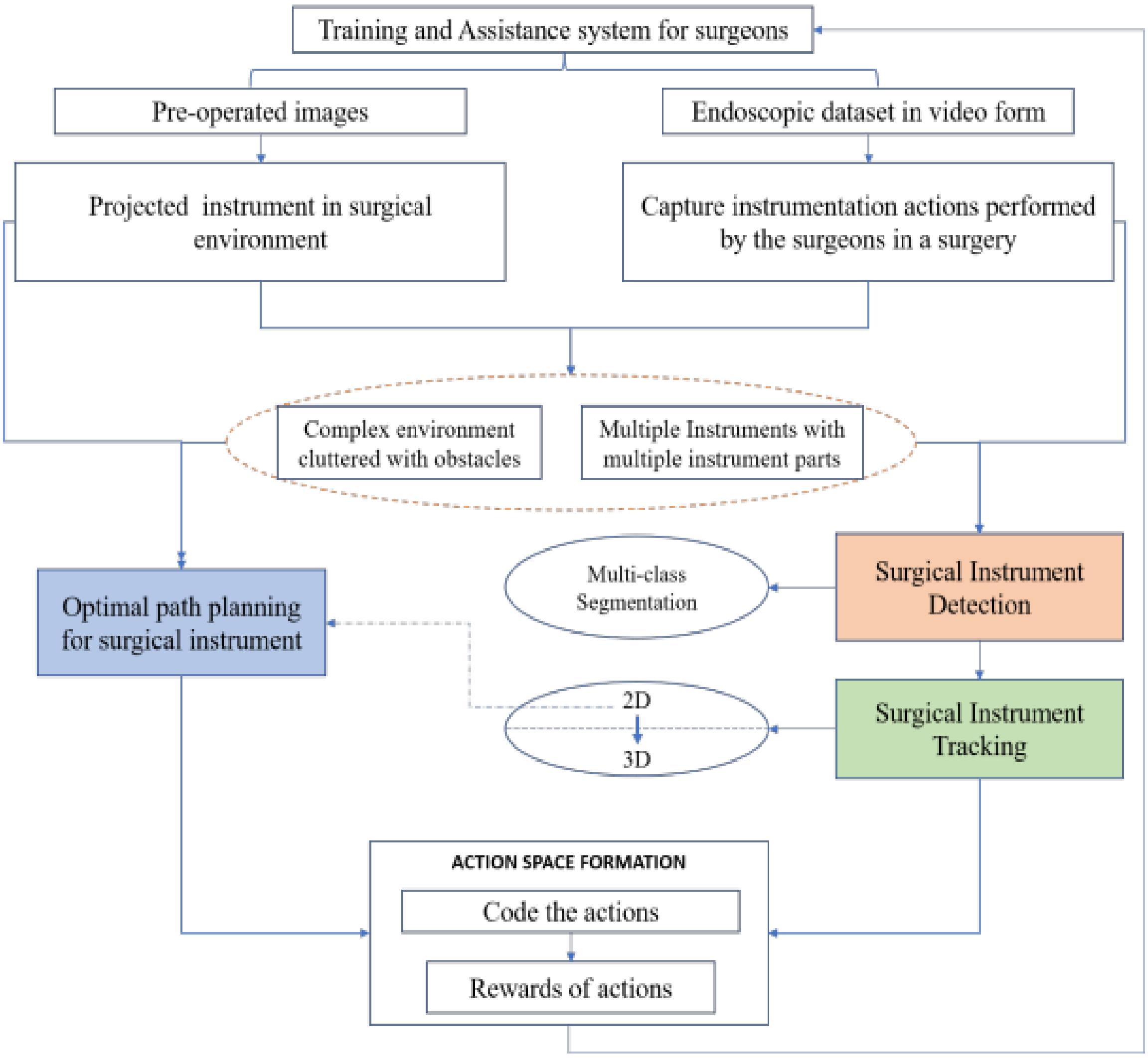

Figure 1: Various stages in Surgical Action Analysis for training and assistance system

These systems facilitate interaction with technological additions, help identify surgical actions during any operation, and offer support and guidance based on the surgical acts and situation. In medicine and healthcare, surgical instruments and tools are frequently utilized for a variety of purposes. These instruments are capable of reaching challenging locations inside the patient's body with little harm to them and without coming into contact with vital organs [8]. The development of medical imaging techniques has made it possible to gather real-time patient-specific information. Minimally Invasive Surgery (MIS) is performed with the use of these procedures. A safe, practical, and patient-friendly method of carrying out a surgical intervention is MIS [5]. However, because of its novel interaction model that excludes the typical sensory cues, MIS has significant restrictions for surgeons[10]. Using an endoscope (camera) to indirectly visualize the surgical region, this procedure is based on the indirect manipulation of specialist surgical instruments[6]. The primary goal of the MIS video analysis is to create solutions that address two fundamental clinical needs: 1) Improved instruction and impartial assessment of MIS competencies, and 2) improved insight and support for the development of real-time navigation systems in the surgical area. [11].

MATERIALS AND METHODS

We keep going back and forth via many layers until we eventually get at an output. Every evaluation builds on the output of the layer before it in its own layer. Since we are unable to view their inputs and outputs, these layers are frequently referred to as hidden layers. For instance, a colonoscopy image is multiplied before being analysed to identify polyps. After that, it passes through a number of filters, each of which produces a score that is sent to the following set of filters, such as those for edge and colour detection [7]. We refer to this layered method as "deep learning" because it goes through multiple phases." Each filter produces an output score that serves as the input for the layer that follows, regardless of whether the final outcome is a diagnostic conclusion or the identification of a polyp in the image. As we discussed earlier, two aspects of the digital world that use mathematical methods to enhance learning via experience are machine learning (ML) and deep learning (DL).

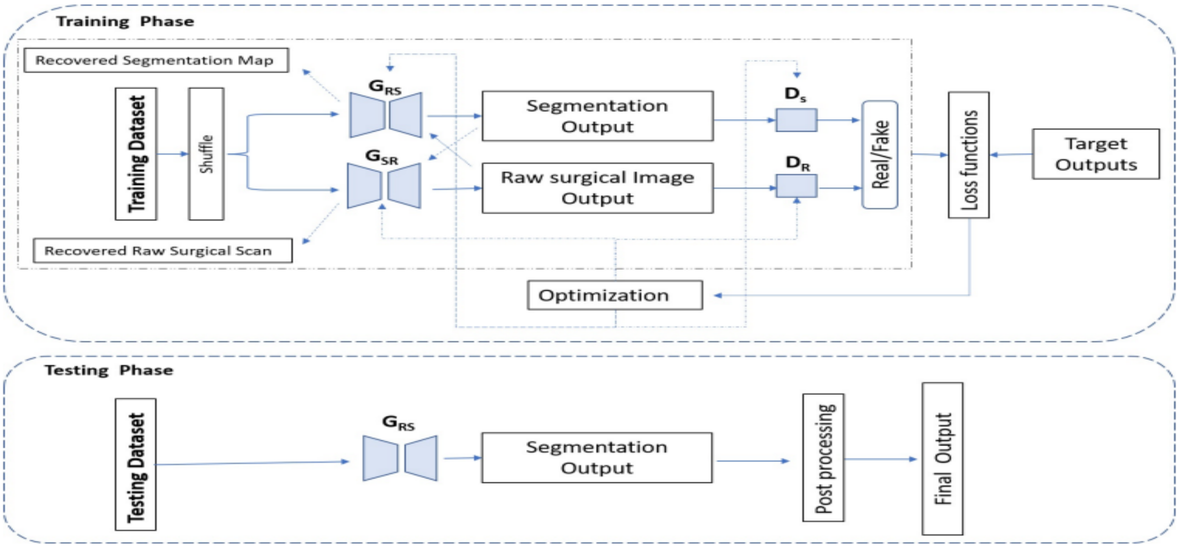

Figure 2: system design

Physical AI includes devices like medical equipment and other AI-powered devices. For instance, robot companions have been developed to assist elderly individuals who are suffering from cognitive decline and mobility issues. AI is also being utilized to assess human performance in rehabilitation programs [12]. Nanorobots have also been developed to control and observe human medicine delivery systems. In this sense, AI and ML are essential for assessing and determining how effective treatments are.

RESULT AND DISCUSSION

Gulshan and his colleagues developed a deep learning algorithm that can recognize diabetic retinopathy by analysing retinal fundus images, which is a cutting-edge application of deep learning in medicine. Their method was trained on a dataset of 128,175 retinal images that had been previously analysed by ophthalmologists. The result? Diabetic retinopathy can be detected in new images with a remarkable 97.5% sensitivity and 93.4% specificity.

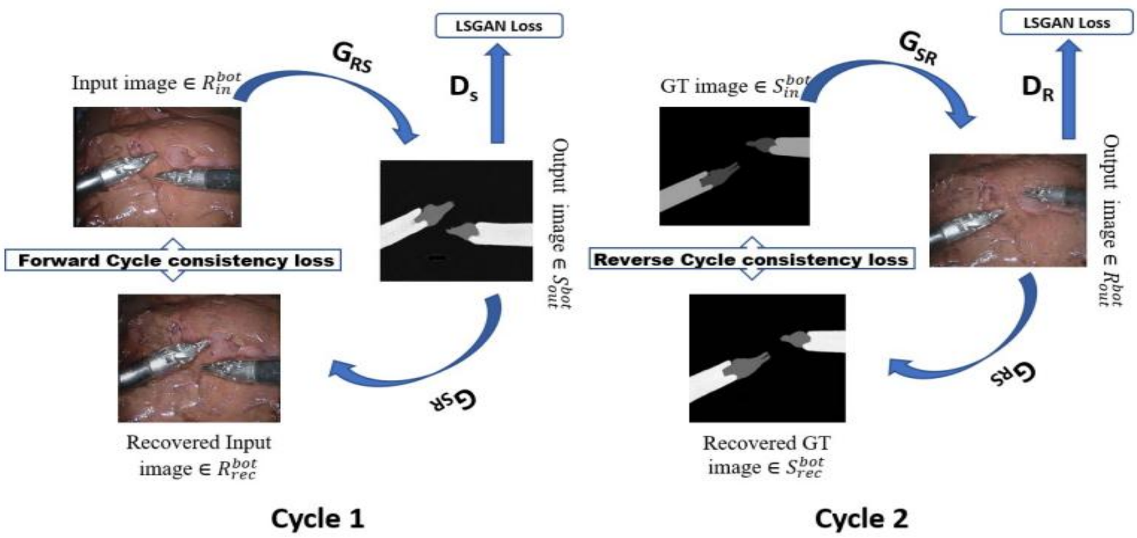

Figure 3: Unpaired training pipeline

These findings have important ramifications for screening and service provision, particularly if they can be reliably confirmed in practical contexts. Deep learning (DL) adoption has advanced quickly in various therapeutic domains because of favourable circumstances including digitalization and data abundance[14]. This is especially true in disciplines like pathology, ophthalmology, dermatology, radiology, radiation, and image-guided surgery. However, due to a number of obstacles, growth in other sectors has halted, and in other cases, it hasn't even started.

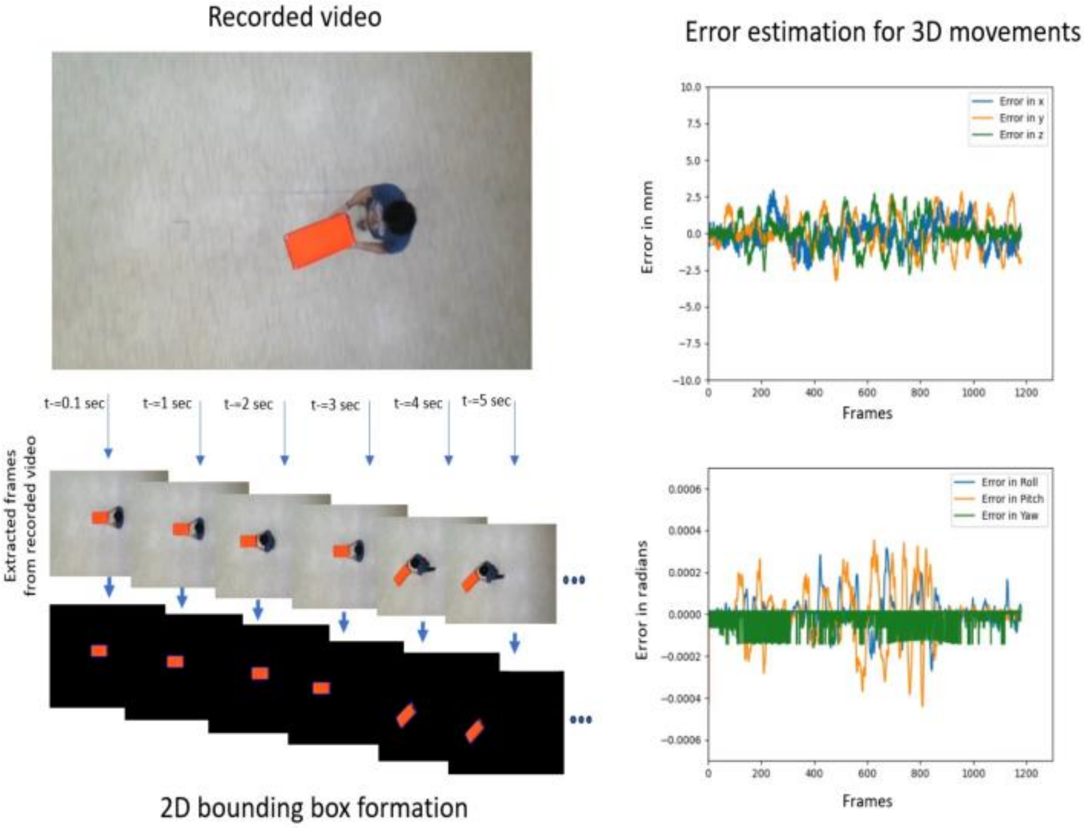

Figure 4: Experimental Validation

The advanced autonomous features of today's medical robots are taking over the simpler automation tasks that the first generation of these machines handled. With minimal official regulations and a host of challenging ethical dilemmas, the legal and moral implications of robots performing autonomous actions continue to spark lively debates [15].

CONCLUSION

In the not-so-distant future, we can expect robotic technology to revolutionize the world of surgery. Robots may now function in both autonomous and semi-autonomous modes because to developments in artificial intelligence, machine learning, and deep learning. Enhancing this autonomy in a variety of surgical procedures is becoming more and more popular, from well-known procedures like cochlear implants to innovative methods like totally autonomous intestinal anastomosis. In the future, it is expected that robotic systems will make important treatment decisions as their autonomy increases. Due to legal restrictions, medical organizations—rather than government agencies like the FDA—usually supervise medical activities; this change could present a new regulatory problem. However, these businesses usually lack the technical expertise needed to evaluate these complex and rapidly evolving technologies.

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