Computer Vision in Hospitals

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Introduction

In this paper, we examine the current state-of-the-art applications of Computer Vision in hospitals, focusing specifically on its role in surgeries.

The use of artificial intelligence (AI) in hospital settings has grown significantly in recent years. Advances in AI techniques, particularly in how these systems are developed and trained, have enabled the medical community to enhance its methods and practices. Among the many fields benefiting from these advancements, Computer Vision stands out as one of the most impactful in medicine. When applied effectively, Computer Vision aids healthcare professionals in diagnosing conditions and performing surgeries more efficiently and accurately.

Computer Vision is a subfield of artificial intelligence that leverages machine learning, particularly deep learning and neural networks, to extract meaningful information from visual data, such as digital images and videos. Deep learning algorithms, with their ability to process and learn from large volumes of data, have revolutionized Computer Vision by enabling the development of highly accurate models for image recognition, segmentation, and analysis. This synergy between Computer Vision and deep learning has proven invaluable in transforming how medical professionals approach complex tasks, streamlining processes, and improving patient outcomes [1].

Keywords: Computer Vision, Surgery, Artificial Intelligence, Deep Learning

State of the art

In this section, we will explore the current applications of Computer Vision in the medical field and highlight various scenarios where it is utilized.

Computer Vision is primarily applied in minimally invasive surgeries, with a focus on imaging, navigation, and guidance. Its tasks can be broadly categorized into four areas: image classification, object detection, semantic segmentation, and instance segmentation [3].

Efforts in image classification using Computer Vision are currently directed toward automated step identification. This capability allows the system to recognize the current phase of a surgery and predict the remaining duration of that phase [3].

For object detection, Computer Vision systems can now locate and identify surgical objects within an image by generating bounding boxes and labels for each object. This enables precise identification and tracking of tools and other items during surgical procedures [4].

Semantic segmentation plays a crucial role in intraoperative guidance. This process involves dividing an image into labeled regions at the pixel level. By analyzing the role of each pixel, semantic segmentation enables the definition of object boundaries, providing dense, pixel-based predictions that are invaluable for guiding surgeons [3].

Instance segmentation, on the other hand, is particularly useful when dealing with overlapping objects. Even when objects share the same label, instance segmentation can identify their relationships, differences, and boundaries. This capability is especially important for distinguishing between surgical instruments that intersect or overlap in complex ways during surgery [3].

One of the most prominent surgeries currently utilizing Computer Vision is laparoscopic surgery. During these procedures, Computer Vision is employed for workflow recognition, identification of anatomical structures, detection of surgical instruments, and monitoring of operational actions. These applications significantly assist surgeons, enabling them to perform surgeries more efficiently and safely [5].

Computer Vision is also being tested and occasionally used to analyze surgical outcomes. For instance, a Computer Vision algorithm has been applied to evaluate the results of upper eyelid surgery. This algorithm was designed to detect faces and identify facial landmarks in profile photographs of patients who had undergone upper eyelid blepharoplasty, with or without Müller's muscle-conjunctival resection (MMCR) [7].

Conclusion

Currently, Computer Vision is a technology still in the testing phase and is not yet widely used in the surgical context. Most of its applications are focused on diagnosis and research studies.

Although some studies have successfully demonstrated the use of Computer Vision to assist surgeons during procedures—improving orientation and efficiency—the technology is not yet advanced enough for consistent, widespread use in surgeries. However, with further development, Computer Vision has the potential to become an incredibly powerful and valuable tool within the medical community, benefiting surgeons, surgical interns, and medical students in their tasks and training [6].

Future surgical applications of Computer Vision could include quality improvement, analysis of operative complexity, operative assessment and feedback, intraoperative decision support, and assistance with operating room (OR) team dynamics [2].

In the described applications of Computer Vision (CV) in surgery, the primary tasks—image classification, object detection, semantic segmentation, and instance segmentation—are still heavily reliant on human oversight. These tasks depend on annotated datasets, clinical validation, and careful monitoring to ensure accuracy in real-world scenarios, such as workflow recognition, tool tracking, and anatomical structure identification.

Generative AI contributes indirectly to these efforts by generating synthetic data to augment training datasets, enhancing image quality during surgeries, and creating realistic simulations for model testing and surgeon training. While the core applications of CV remain clinically validated and human-centered, generative AI serves as a supplementary tool, optimizing performance and extending the capabilities of CV systems.

References

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