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An Examination of the Use of Artificial Intelligence in Orthopaedic Surgery

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Abstract:- Artificial intelligence (AI) is being used more and more in numerous fields, and the medical industry is no exception. AI is demonstrating potential as a helpful tool in all facets of patient care pathways, including research in healthcare. Due to the practically exponential expansion in computer processing power, cloud computing, and the invention and improvement of software algorithms specifically designed for medical tasks, artificial intelligence (AI) systems are becoming more and more significant in the fields of medicine and orthopaedic surgery. Machine-based integration of imaging studies is particularly ripe for the field of orthopaedic disorders because of the extensive role of technologies like medical imaging that bring high sensitivity, specificity, and positive/negative prognostic value to the management of orthopaedic disorders, among other applications. In orthopaedic surgery, practical applications include real-time rehabilitation monitoring and surgical training; predictive models of clinical and patient-reported outcome measures, such as calculating mortality rates and length of hospital stay; and diagnostics, such as fracture recognition and tumor detection. This study aims to outline current clinical uses of AI in orthopaedic surgery and to provide a thorough grasp of AI and its subfields.

Keywords:- *Artificial Intelligence, Orthopaedics, Orthopaedic Surgery, Machine Learning, Deep Learning.*

I. INTRODUCTION

As a specialty area focused on treating diseased and traumatizing disorders of the bones, joints, and connective tissues, orthopaedic surgery presents a special opportunity for machine learning integration. This is a result of radiography and computed tomography (CT) providing a great image of the skeleton and their ability to capture minor skeletal disease. The variety of imaging investigations in orthopaedics is further enhanced by the excellent sensitivity and specificity of instruments like as magnetic resonance imaging (MRI) in identifying soft-tissue injuries. There is a lot of potential for machine-based integration in orthopedic surgery, particularly with regard to imaging studies. AI systems are capable of analyzing complicated imaging data, which helps with accurate diagnosis and individualized treatment planning. Beyond just diagnostics, this integration affects many aspects of orthopaedic practice, such as postoperative care, real-time intraoperative guiding, and surgery planning. The use of AI in orthopaedic surgery improves diagnosis efficiency and accuracy while creating new opportunities for creative surgical approaches[2]. This all helps to promote patient care in this specialty area of medicine. artificial intelligence (AI), emphasizing that use in the medical field that AI is composed of many sub-branches (Figure 1).

II. WHAT IS AI?

AI has the capacity to address many of the problems that are affecting modern society and healthcare. Determining what AI is can be challenging. But as the excitement around AI is sometimes misapplied to numerous new technologies or products that might not actually fit the definition, it becomes imperative to grasp what AI actually is. Fundamentally, artificial intelligence (AI) is about creating machines that are capable of doing tasks that are inherently human. This covers activities like organizing, learning, identifying patterns, comprehending language, and solving problems. Most crucially, AI is capable of improving and learning from errors, much like experiential learning.

III. MACHINE LEARNING

ML was first presented at IBM in 1959 as a means of obtaining AI, not long after AI. Enabling computers to adapt and predict desired outputs based on inputs without explicit programming is the main objective of machine learning (ML). With its ability to function both under human supervision and independently (supervised vs. unsupervised ML), ML has a wide range of potential medical applications. Both supervised and unsupervised machine learning approaches have been applied extensively in orthopaedics; each has pros and cons. Algorithms in supervised learning follow human-defined ground truth, which facilitates

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implementation and increases its interpretability during decision-making. However, producing high-quality ground truth involves a lot of physical labor and could introduce biases from people. Conversely, unsupervised learning extracts knowledge straight from data, enabling data-driven choices free from outside prejudices. Both strategies advance clinical applications and orthopaedic research.

➢ *Deep Learning*

A branch of machine learning known as "deep learning" makes use of multi-layered neural networks, or "deep neural networks," to mimic the intricate decision-making abilities of the human brain by combining data inputs, weights, and bias. Together, these components enable precise item identification, classification, and description within the data.

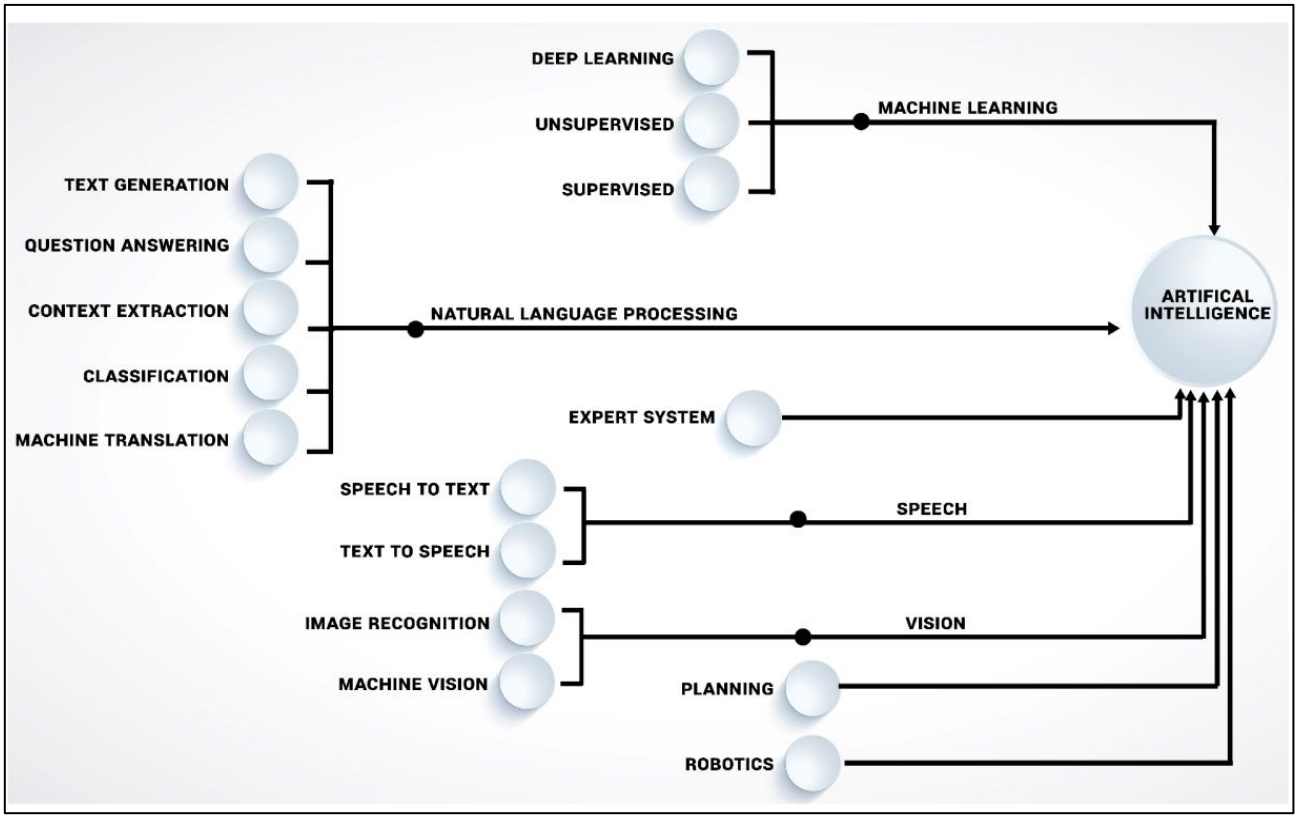

Fig 1: Illustrating the Key Disciplines of Artificial Intelligence (AI), Including Machine Learning (ML) Approaches that are Influencing Orthopaedics Research[2].

➢ *Image Recognition and Diagnostics:*

The integration of sophisticated picture recognition and diagnostic techniques has revolutionized patient treatment in the field of orthopaedics. Convolutional Neural Networks (CNNs), which are excellent at automatically extracting complex information from radiography images, are one of the most used methods. These CNNs are essential for accurate insights to healthcare practitioners in jobs ranging from joint state assessment to fracture detection. Furthermore, a more thorough and sophisticated understanding of orthopaedic disorders is made possible by deep learning algorithms, which are included in Computer-Aided Diagnosis (CAD) systems. These systems are helpful tools that provide other perspectives by pointing up possible anomalies in medical imaging.

Second In order to accurately identify and delineate particular structures or regions of interest within orthopaedic images and enable quantitative analysis, segmentation techniques are essential. Furthermore, in order to improve diagnosis accuracy, pattern recognition algorithms play a key role in recognizing distinctive patterns connected to different orthopaedic disorders. The application of three-dimensional imaging and reconstruction methods, such CT and MRI scans, provides a three-dimensional view that is very helpful in the diagnosis of intricate orthopaedic problems like spinal diseases or joint abnormalities.

Third, textual reports connected to orthopedic photographs can have useful information extracted from them using Natural Language Processing (NLP) techniques, which serve as a complementary tool to image analysis. A comprehensive grasp of the patient's condition and medical history is ensured by this integration. The diagnostic potential of orthopaedics is further enhanced by transfer learning, ensemble approaches, and augmented and virtual reality (AR and VR) technologies, all of which enhance surgery planning, training, and patient care in general. As these cutting-edge techniques develop further, their incorporation highlights a paradigm shift in orthopaedic diagnostics that improves accuracy, productivity, and the general standard of patient outcomes.

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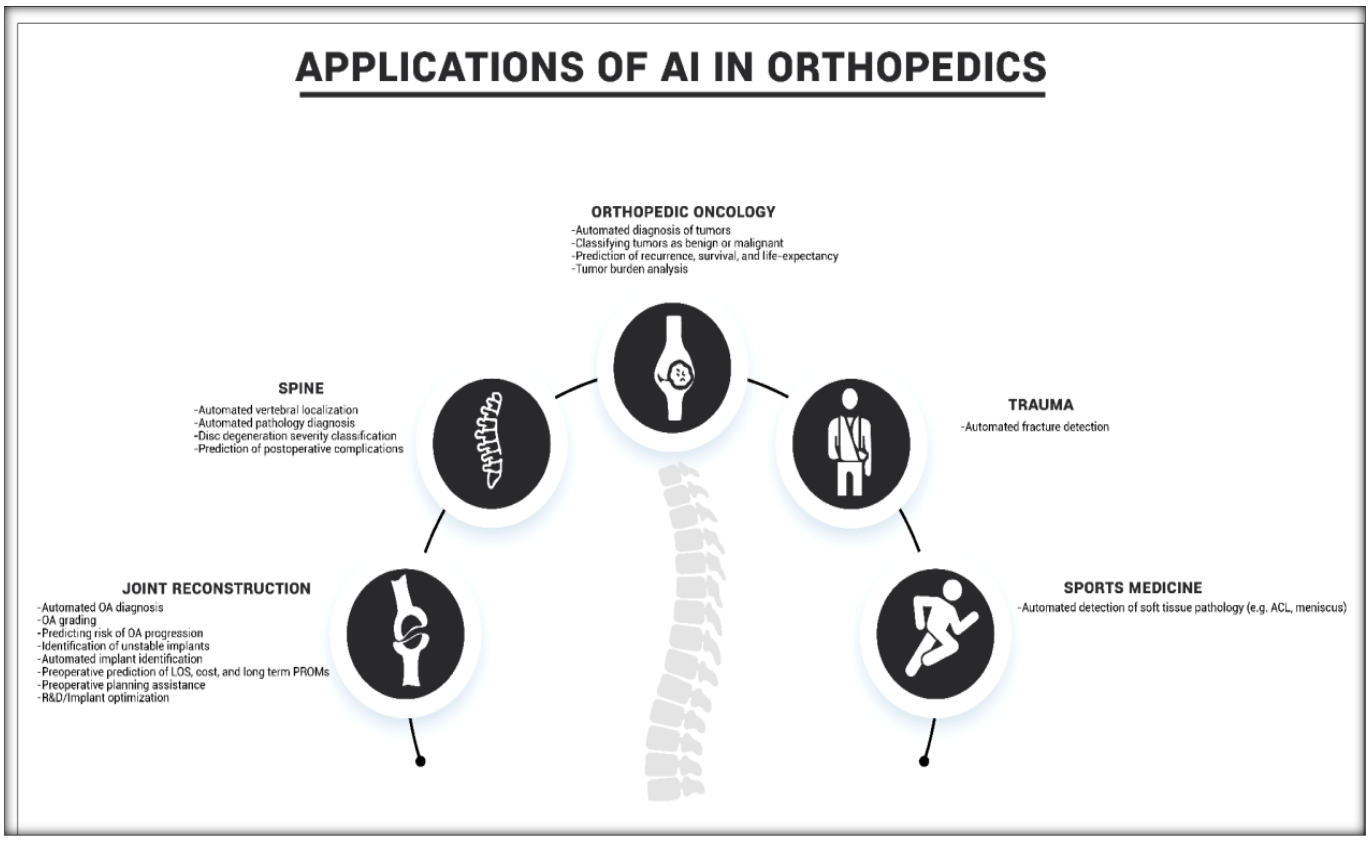

Fig 2 Common Applications of AI in Orthopaedics.

➢ *Spine*

Image-guided surgery is one of the most exciting areas in which artificial intelligence is being applied to spine surgery. AI-based algorithms are able to evaluate preoperative spine images, like CT or MRI scans, and offer real-time advice while the surgery is being performed. This can lower the chance of problems and increase the precision of spinal instrumentation[2].

IV. AUTOMATED IMAGE-BASED DIAGNOSIS

The application of artificial intelligence to the analysis of medical pictures, such as X-rays, CT scans, and MRIs, in order to diagnose and assess spinal problems is known as automated image-based diagnosis in spine orthopaedics. Advanced algorithms are usually used in this procedure, especially those that are based on machine learning and deep learning methods[2].

The steps involved in using this automated diagnosis are as follows:

- Data collection: Patients with spinal issues provide pertinent medical pictures, frequently in the form of X-rays, CT scans, or MRIs. The AI system uses these pictures as its input data.
- Preprocessing: To improve their quality and prepare them for analysis, the gathered photos go through preprocessing. To guarantee consistency in the data, this may entail performing operations like normalization, resizing, or filtering.
- Anatomical Localization: Anatomical localization refers to the ability of AI algorithms to identify and pinpoint particular anatomical structures in the spine, including intervertebral discs, vertebrae, and other pertinent aspects. Accurate identification and assessment depend on this phase.
- Feature Extraction: Feature extraction involves taking characteristics from the photos, such as textures, forms, and pixel values. Convolutional neural networks (CNNs), one of the best deep learning models, are excellent in automatically learning and extracting these properties, enabling a more thorough analysis.
- Classification and Diagnosis: To identify different spinal diseases, trained AI models classify the retrieved features. This could involve classifying fractures, determining the degree of disc degeneration, identifying anomalies, or forecasting difficulties following surgery.
- Localization for Procedures: By accurately localizing anatomical features, the AI system can help with planned surgical or interventional operations. For instance, it can pinpoint the precise vertebral level needed for an epidural injection or spinal surgery.
- Reporting and Communication: By producing consistent reports and classifications, the AI system improves communication amongst healthcare professionals. Decision-making, cooperation, and documentation can all be facilitated by these reports.

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V. CONCLUSION

AI in orthopaedics offers the potential to lessen medical staff workloads and enhance patient outcomes. AI is already playing a big part in medicine thanks to the exponential rise in computer processing capacity, the introduction of cloud computing, and the creation of specialized software algorithms. The incorporation of AI has demonstrated significant promise, particularly in machine-based imaging studies, especially in orthopaedic surgery.

With its wide range of applications in orthopaedic illnesses and its excellent predictive value, sensitivity, and specificity, medical imaging technologies are a perfect fit for artificial intelligence. Predictive models for clinical and patient-reported outcomes are just one example of the practical uses in orthopaedic surgery, along with real-time rehabilitation monitoring and surgical training. AI also helps with diagnostics, helping with things like tumor and fracture identification.

This paper highlights the diverse contributions of artificial intelligence (AI) in orthopaedic surgery by giving a summary of the field's current clinical uses. With AI's further development, patient treatment pathways stand to be significantly reshaped and optimized, leading to more effective and individualized orthopaedic healthcare delivery. AI has the potential to improve patient outcomes in terms of diagnosis, treatment planning, and overall outcomes, as demonstrated by the continuous research and application of AI in orthopaedic surgery.

REFERENCES

[1]. Thomas G. Myers, MD, MPT,1,a Prem N. Ramkumar, MD, MBA,2 Benjamin F. Ricciardi, MD,1 Kenneth L. Urish, MD, PhD,3 Jens Kipper, PhD,4 and Constantinos Ketonis, Artificial Intelligence and Orthopaedics doi: 10.2106/JBJS.19.01128.

[2]. Faraz Farhadi1,2*, Matthew R. Barnes1, Harun R. Sugito1, Jessica M. Sin3, Eric R. Henderson4 and Joshua J. Levy5 *. Applications of artificial intelligence in orthopaedic surgery DOI 10.3389/fmedt.2022.995526.

[3]. Cabitza F, Locoro A, Giuseppe B. Machine learning in orthopedics: a literature review. Front Bioeng Biotechnol. 2018;6:75.

[4]. Rodrigo de Marinis, MDa,b,c, Erick M. Marigi, MDa, Yousif Atwan, MD, MSca, Linjun Yang, PhDd , Jacob F. Oeding, MSa, Puneet Gupta, BSe , Ayoosh Pareek, MDf, Joaquin Sanchez-Sotelo, MD, PhDa, John W. Sperling, MD, MBAa,* Current clinical applications of artificial intelligence in shoulder surgery: what the busy shoulder surgeon needs to know and what's coming next.

[5]. Choy G, Khalilzadeh O, Michalski M, Do S, Samir AE, Pianykh OS, et al. Current applications and future impact of machine learning in radiology. Radiology. 2018 Aug;288(2):318–28.

[6]. Takagi Y, Sakai Y, Lisi G, Yahata N, Abe Y, Nishida S, et al. A neural marker of obsessive-compulsive disorder from whole-brain functional connectivity. Sci Rep. 2017;7:7528.

[7]. Toosi A, Bottino AG, Saboury B, Siegel E, Rahmim A. A brief history of AI: how to prevent another winter (A critical review). PET Clin. (2021) 16(4):449–69. doi: 10.1016/j.cpet.2021.07.001.

[8]. Khan AA, Laghari AA, Awan SA. Machine learning in computer vision: a review. EAI Endorsed Scal Inf Syst. (2021) 8(32):e4. doi: 10.4108/eai.21-4-2021.169418.

[9]. 1Institute of Advanced Orthopedics, M.O.S.C Medical College Hospital, Kolenchery, Ernakulam, Kerala, India Address of Correspondence: Dr. Prannoy Paul, Institute of Advanced Orthopedics, M.O.S.C Medical College Hospital, Kolenchery, Ernakulam, Kerala, India. The Rise of Artificial Intelligence: Implications in Orthopedic Surgery doi: 10.13107/jocr.2024.v14.i02.4194.

[10]. Kurmis, A.P., Ianunzio, J.R. Artificial intelligence in orthopedic surgery: evolution, current state and future directions. Arthroplasty 4, 9 (2022). https://doi.org/10.1186/s42836-022-00112-z.

[11]. Helm JM, Swiergosz AM, Haeberle HS, Karnuta JM, Schafer JL, Krebs VE, et al. Machine Learning and Artifcial Intelligence: Defnitions, Applications, and Future Directions. Curr Rev Musculoskelet Med. 2020;13(1):69–76.

[12]. Myers TG, Ramkumar PN, Ricciardi BF, Urish KL, Kipper J, Ketonis C. Artifcial intelligence and Orthopaedics: an introduction for clinicians. J Bone Joint Surg Am. 2020;102(9):830–40.

[13]. Liu, P., Zhang, J., Liu, S. et al. Application of artificial intelligence technology in the field of orthopedics: a narrative review. Artif Intell Rev 57, 13 (2024). https://doi.org/10.1007/s10462-023-10638-6
Application of artificial intelligence technology in the field of orthopedics: a narrative review.

[14]. B. Innocenti, Yanislav Radyul, E. Bori Published in Applied Sciences 24 October 2022 Medicine, Computer Science The Use of Artificial Intelligence in Orthopedics: Applications and Limitations of Machine Learning in Diagnosis and Prediction DOI:10.3390/app122110775

[15]. A. Lisacek-Kiosoglous, Amber S Powling, A. Fontalis, A. Gabr, E. Mazomenos, F. Haddad less Published in Bone & Joint Research 1 July 2023 Medicine, Computer Science, Engineering Artificial intelligence in orthopaedic surgery DOI:10.1302/2046-3758.127.BJR-2023-0111.R1.

[16]. R. K. Martin, Christophe Ley, Ayoosh Pareek, A. Groll, T. Tischer, R. Seil less Published in Knee Surgery, Sports… 15 September 2021 Medicine, Computer Science Artificial intelligence and machine learning: an introduction for orthopaedic surgeons DOI:10.1007/s00167-021-06741-2

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAY1495

[17]. Michael J Ormond, N. D. Clement, Ben G Harder, L. Farrow, Andrew Glester Published in Bone & Joint Open 1 September 2023 Medicine, Computer Science Acceptance and understanding of artificial intelligence in medical research among orthopaedic surgeons DOI:10.1302/2633-1462.49.BJO-2023-0070.R1
[18]. Aghnia FN, Lai JY, Wang JC et al (2021) Sanders classification of calcaneal fractures in CT images with deep learning and differential data augmentation techniques. Injury 52(3):616–624
[19]. Hasan S, Ahmed A, Waheed MA, Saleh ES, Omari A. Transforming Orthopedic Joint Surgeries: The Role of Artificial Intelligence (AI) and Robotics. Cureus. 2023 Aug 10;15(8):e43289. doi: 10.7759/cureus.43289.
[20]. Research and application of artificial intelligence based three-dimensional preoperative planning system for total hip arthroplasty (Article in Chinese) Wu D, Liu X, Zhang Y, Chen J, Tang P, Chai W. Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi. 2020;34:1077–1084.