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AI: Vision And Reality (CS4710)

AI-Enhanced Medical Imaging: Compression and Diagnosis

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Abstract:

In the sector of present-day healthcare, the call for green garages and the transmission of clinical images is growing. With the speedy growth of artificial intelligence, it has made significant access into the field of drugs. In the age of the usage of AI for disorder diagnosis, medical snapshots perform an essential role. The gravity of these pics comes with the aid of the project of handling huge datasets As the assets are continually confined there is a demand for the facts that can be stored and transmitted over the communique bandwidth of remote medical systems the lossless statistics compression of the clinical photograph comes into the photograph. (Xin and Fan, 2021)

This, in turn, plays an essential role in making informed selections. And enables making brief evaluation that helps in the timely treatment of the affected person. The major purpose of this evaluation is to examine existing literature on scientific photograph compression approaches based totally on coding schemes like Huffman coding, mathematics coding, dictionary-based coding, and wavelet remodel-based techniques.

1 Introduction:

Artificial Intelligence means showing human intelligence using machine programs to do the task that requires human intelligence. The introduction of artificial intelligence in medicine holds the ability to bring numerous benefits. Artificial intelligence can analyze medical images, and other medical information with a high degree of accuracy, which supports healthcare professionals in early and precise disease detection. Additionally helps healthcare professionals in timely decision-making. Over time, medical imaging has emerged as a critical component in the process of diagnosing and treating illnesses. The images obtained during diagnostic procedures are archived for future examinations, demanding considerable storage capacity. Consequently, the management and retrieval of these images require substantial effort. Given the significance of the data for analysis, careful consideration is necessary when performing medical image compression. (Srinivasu et al., 2022)

Typically, data compression involves the removal of redundancy and irrelevant information. The compression process operates at two levels (Modelling and Coding): firstly, the data undergoes analysis to identify and extract any redundant information, forming a model. Subsequently, at the second level, the residual, representing the disparity between the modeled and actual data, is computed and encoded using a specific encoding technique. Various methods exist for characterizing data, and the diversity in characterization results in the development of numerous DC (Data Compression) approaches. (Jayasankar, Thirumal and Ponnurangam, 2021)

Various approaches are categorized as lossy and lossless mechanisms for the compression of medical images. True to its name, lossless compression denotes no loss of information; the reconstructed data mirrors the original data precisely. This method finds utility in applications where preserving information integrity is paramount, such as in the text, “medical imaging, law forensics, military imagery, satellite imaging,

and more". (Jayasankar, Thirumal and Ponnurangam, 2021,p. 6). In contrast, there are situations where opting for lossy compression techniques is more advantageous. In these cases, the reconstructed data may not perfectly match the original, but an approximation is deemed acceptable. This trade-off results in higher compression ratios for lossy compression techniques when compared to their lossless counterparts. (Jayasankar, Thirumal and Ponnurangam, 2021)

This paper predominantly explores medical image compression based on coding schemes. They decompose the image into different frequency components, allowing for efficient representation and compression. Going further into the hierarchy, this paper will discuss the AI-driven solutions that have been using medical image compression techniques like JPEG2000 (Joint Photographic Experts Group 2000) for image compression.

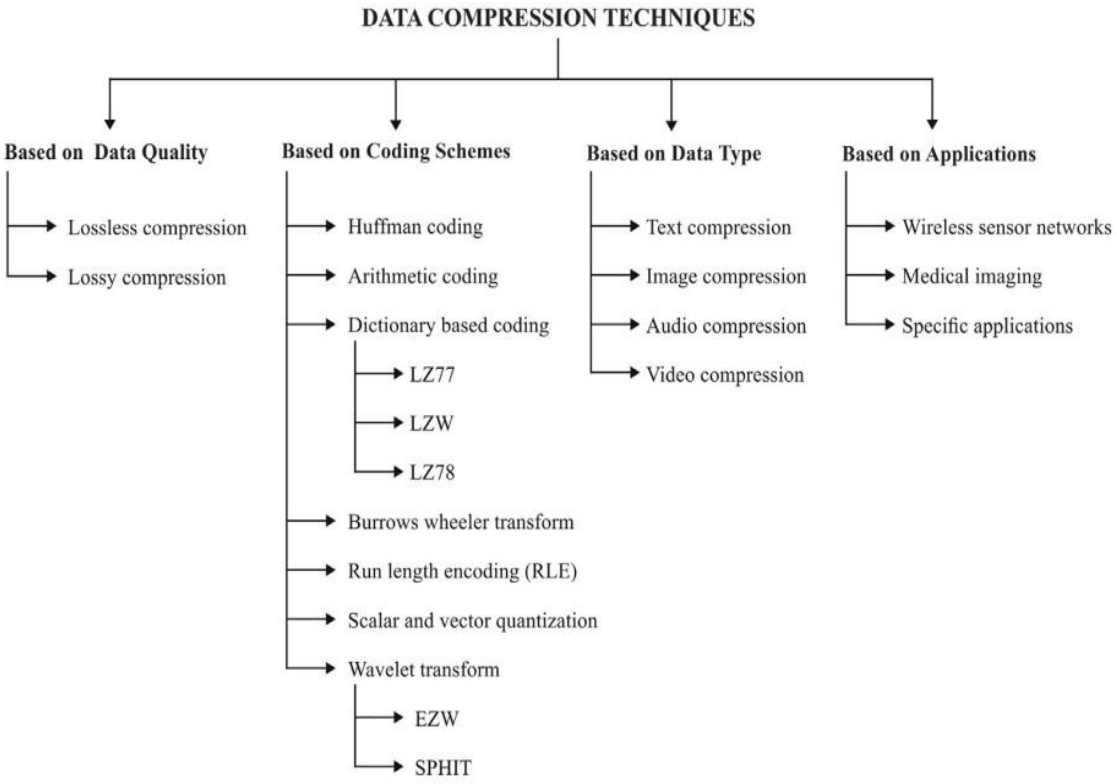
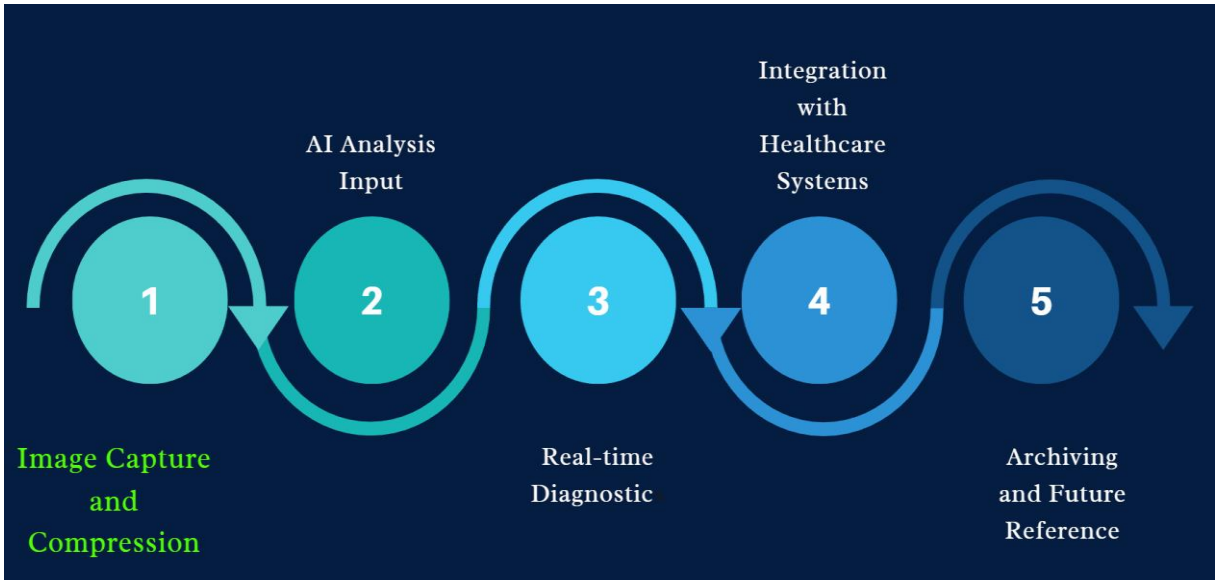


Fig 1: Classification model

(Jayasankar, Thirumal and Ponnurangam, 2021)

2 Background

In the hastily evolving panorama of healthcare, the fusion of artificial intelligence (AI) and scientific imaging technologies has become a transformative force. This report discusses the critical function of medical image compression strategies in the context of AI-driven answers for ailment analysis. As the capability of AI has been growing unexpectedly, AI has made a tremendous front in the medical field main medical specialists depend on superior AI algorithms to understand complicated visible facts, and the proper management of massive-scale clinical photographs has become critical. This document explores one-of-a-kind clinical picture compression methods like Huffman coding, and wavelet rework, that optimize the garage, transmission, and processing of medical images. These compressed images, serving as inputs to AI-based healthcare systems, permit short and early detection of ailment. The synergy among the image compression and AI technologies not simplest streamlines information control but also increases the accuracy and the velocity of sickness detection. This record navigates the intersection of medical photograph compression and AI programs, illustrating their collective impact on growing precision in healthcare diagnostics. Below are the phases that AI solutions need to undergo.



3 Overview of coding Scheme based image compression.

This section describes, the popular compression techniques based on coding schemes such as Huffman coding, and transform coding methods which are considered the ancestors in the field of data compression are reviewed.

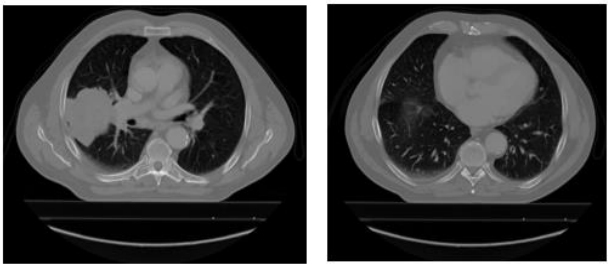
- **Huffman Coding**

One of the most well-known strategies used to compress records in several types of files is called Huffman coding. The most effective prefix code is an awful lot used in lossless information compression. (Alkawaz, Mydin and Johar, 2022). This basic idea lies in the assignment of those variable-period codes to input symbols whose opportunity of recurrence is low for a few and high for others. (Patidar, Kumar, and Kumar, 2023). This consequences in an adaptive code desk for encoding supply symbols. Huffman coding, being uniquely decodable, contains two essential additives: constructing a Huffman tree from the enter after which traversing the tree to assign code phrases for every person within the enter. Huffman coding remains so famous because of its simplicity, high velocity of compression, as well as no patents overlaying it. Types of Huffman coding include “Minimum Variance Huffman Code, Canonical Huffman Code, Length-restricted Huffman Code, Non-binary Huffman Code, Adaptive Huffman Code, Golomb Code, Rice Code, and Tunstall Code” (Jayasankar, Thirumal and Ponnurangam, 2021, p. 6) It is critical to word that huffman coded underpins most of modern compression technology, such as deflate, jpeg or mp3 to mention few, stressing its persisted usefulness for this purpose. (Jayasankar, Thirumal and Ponnurangam, 2021)

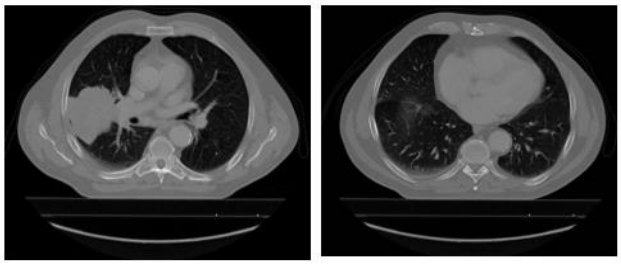
A. Original X-Ray Image

A. Compressed X-Ray Image

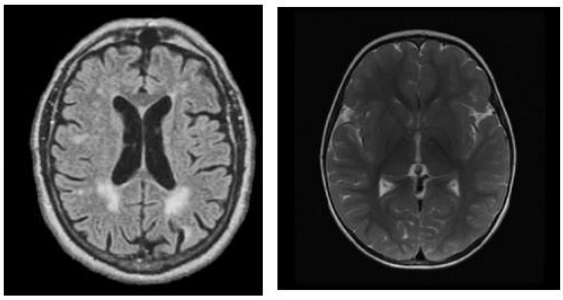
C. Original CT-Scan Image



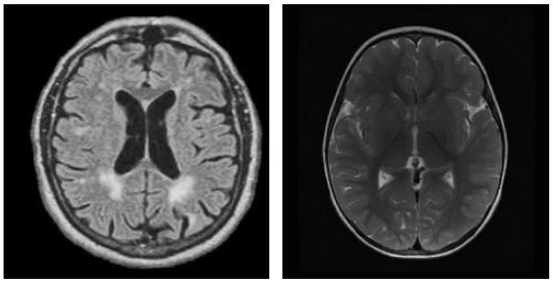
C. Compressed CT Scan Image



B. Original MRI Image



B. Compressed MRI Image



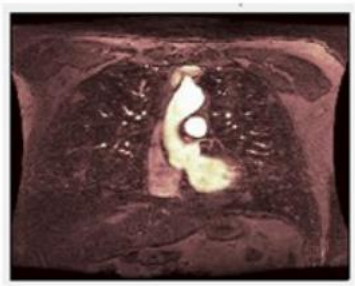
(Alkawaz, Mydin and Johar, 2022).

➢ Wavelet Transform

The wavelet transform translates the input data into a novel space characterized by basic functions that exhibit significant localization in space, typically featuring compact support.

The term 'wavelet' is derived from the notion of a localized wave-like function. Wavelets demonstrate localization not only in space but also in frequency, showing a limited rate of variation. (Jayasankar, Thirumal and Ponnurangam, 2021). Often wavelet transform shows the representation of the results as a pyramid. Wavelet transforms are computationally efficient, as they are defined on a finite domain. Also, wavelet transform allows exact restructuring of the original data.

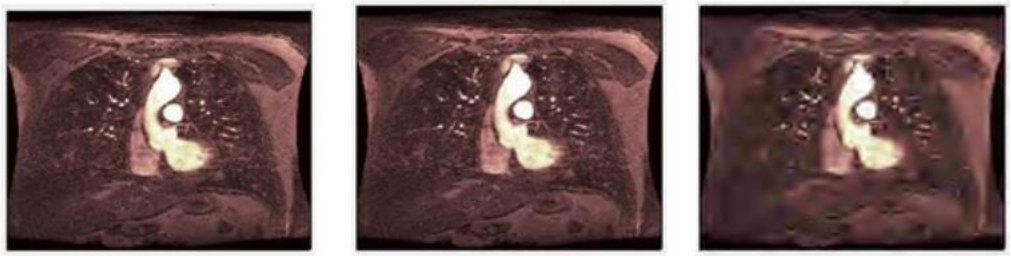
Unlike Fourier analysis, wavelet analysis is not constrained to a single unique solution; instead, numerous sets of wavelets are available for selection. A key trade-off among various wavelet sets lies in their balance between compactness and smoothness. The wavelet transform excels in handling 'choppy' data. (Jean-Luc Starck, 2009)



Original frame of MRI

Image Compression using the JPEG2000 algorithm by explicitly giving a compression ratio

Compression Ratio:06	Compression ratio:10	Compression Ratio:100



(Agarwal*, Salimath and Alam, 2018)

Some of the other commonly used medical image compression techniques are arithmetic coding and dictionary-based coding, **arithmetic coding** is a monochromatic lossless image compression technique, devoid of alphabet extension in source models, is devised. This method has two key phases: modeling and coding. In the modeling phase, a chosen structure dictates event conditioning, and the relative frequencies of conditioned events are subsequently gathered. These frequencies undergo coding by the coding unit to construct the code string. (Jayasankar, Thirumal and Ponnurangam, 2021). **Dictionary-based coding** methods prove advantageous in scenarios where the original data contains repetitive patterns. These approaches operate by encoding patterns with an index to a dictionary when they appear in the input sequence. In cases where a pattern is absent in the dictionary, less efficient coding approaches are employed. (Jayasankar, Thirumal, Ponnurangam 2021)

4 AI Applications in Healthcare

The use of AI has been increasing swiftly in the field of medicine to examine clinical photographs and offer insights into what is going on in the patient. JPEG 2000 is a wavelet-primarily based picture compression that offers excessive compression ratios while retaining appropriate photo excellence, making it a suitable preference for medical imaging packages.

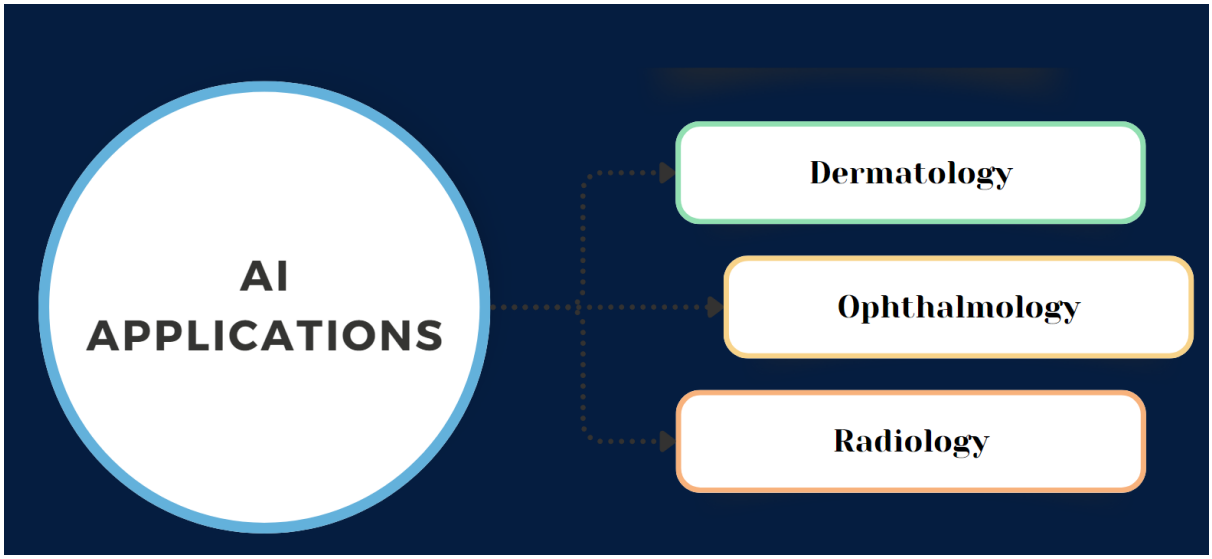
Some of the AI answers being used in healthcare that uses JPEG 2000 compressed clinical photo as input are:

1. Dermatology: The AI algorithm that is used to come across skin cancer with higher precision is skilled on a massive dataset of JPEG 2000 compressed dermatoscopic pics. The set of rules can discover any skin lesions and understand subtle patterns that may indicate malignancy, supporting dermatologists in early cancer detection. (ex: DermExpert)

2. Ophthalmology: An AI-powered device is being advanced to discover diabetic retinopathy; a leading cause of vision loss this machine makes use of JPEG 2000 compressed retinal pix to come across diabetic retinopathy. This machine can identify subtle abnormalities in retinal vasculature, supporting early detection and prevention of vision loss. (ex: IDx-DR)

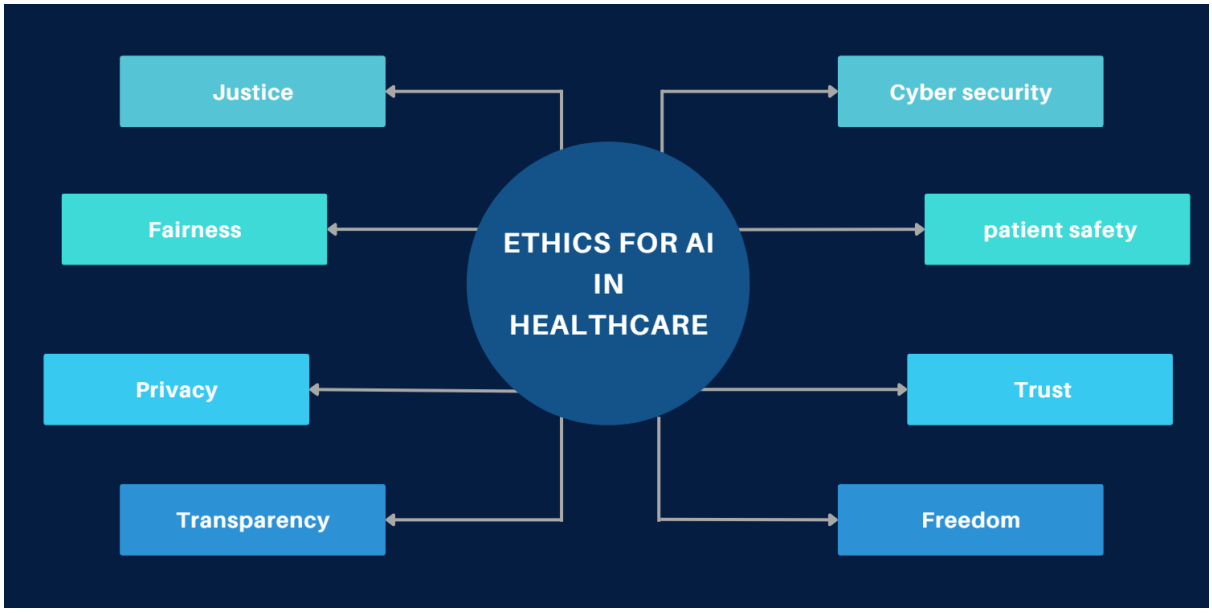
3. Radiology: Radiology pictures like X-rays, CT scans (Computed Tomography Scan), and MRIs (Magnetic resonance imaging), are used to hit upon and diagnose diverse clinical conditions and the AI set of rules that is used to study these medical snapshots makes use of JPEG 2000 compressed radiology snapshots. These algorithms can become aware of abnormalities in bones, tissues, and organs for sickness detection. (ex: AI21 Labs' Chest X-ray Analysis)

There are many different sub-fields of drugs wherein AI answers are becoming popular like pathology, dental imaging, etc.



5 Ethics for AI in Healthcare

AI has been developed exponentially in recent years and has become part of the day-to-day life of people, this includes in fields like healthcare, transportation, education, and intelligent technology.
Machine learning being the important part of AI, has advanced the development of AI. The field of healthcare is one of the most hopeful application domains for machine learning. The application of AI can facilitate in early detection of cancer faster than before, allowing more quick and accurate disease diagnoses. However, to do this machine learning requires a large amount of data, and it also brings up ethical issues as the data here involves the personal information of patients. Ethics has always been a preference in developing and using AI in any field. As the healthcare domain is a sensitive field as it deals with people's lives and ethical issues mainly in healthcare, the technology must conform to the law, regulations, and privacy principles to ensure the maintenance of confidentiality and security of everyone. In the healthcare domain as the lives of patients are at stake, employing any AI applications requires a proper explanation of those AI algorithms as this acts as the base to build trust, increase transparency, and more engagement. The researchers have undertaken this concern and there have been many efforts that have been made to design explainable AI systems. Apart from explainability, many other ethical concerns need to be discussed when implementing any AI-based solution into the healthcare field, as they are becoming influential factors for accepting AI-based solutions. Some of the policymakers and AI-related professionals have been working on this to reduce the ethical risks associated with AI development. The other ethical risks include justice and "**fairness, freedom and autonomy, privacy, transparency, patient safety and cyber security, trust, beneficence, responsibility, solidarity, sustainability, dignity, and conflicts**". See (Li, Ruijs and Lu, 2023, p. 1)



6 Conclusion

Selecting the most effective compression method for medical photograph compression is predicated on numerous elements, depending upon the character of the medical photos, the specified compression ratio, and the allowable diploma of image exceptional loss. Each compression method possesses wonderful blessings and disadvantages, and the suitability of a specific technique may additionally vary depending on the correct needs of clinical photo applications.

In summary, the numerous array of compression strategies highlights the absence of a universally relevant set of rules throughout all applications. Acknowledging the diversity in compression desires, it is prudent to personalize the selection of the set of rules based totally on the characteristics of the records and the targets of the utility. Whether the emphasis is on compression ratio, photo quality protection, or computational efficiency, a considerate assessment of these factors will steer the selection-making process. As technology progresses and applications transform, the pursuit of ultimate compression answers will persist, underscoring the significance of adaptability and context-conscious selection-making in the ever-evolving area of information compression.

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