Artificial intelligence applied to image diagnosis optimization

T.Annapurna[1], Dr.S.Govinda Rao[*2]
[1,2]Computer Science Department, Gokaraju Rangaraju Institute of Engineering and Technology

Abstract:

The use of technology for diagnostic imaging has grown and optimized the quality of diagnoses, speed of examinations and decreasing the dose level for patients. This work was developed using the exploratory study pattern, through bibliographical research of materials already produced, and aims to verify the presence of Artificial Intelligence (AI) applied to radiology as a means of optimizing diagnostic imaging and awakening professionals in the area on the evolution of technology to obtain a better medical diagnosis, concluding that, in the future, an adaptation of the same may be required for their insertion or permanence in the labour market, showing the importance of AI in radiology so that health professionals should be developed in this area, bearing in mind that its application can bring great benefits to humanity.

Keywords: Radiology, intelligence artificial, diagnostic imaging, covid-19, diagnostic software.

1. Introduction

When researching the concept of artificial intelligence, one comes across very interesting definitions which mention that the term “Artificial Intelligence” (A.I. – A.I. in Portuguese) was used for the first time in 1956 by McCarthy (and developed by great researchers such as Marvin Minky and Herbert Simon) and corresponds in saying that this tool is nothing more than a set of theories and techniques used in order to develop machines capable of simulating human intelligence [1, 2, 3, 4, 5, 6, 7].

AI refers to the branch of computer science dedicated to developing computer algorithms to perform tasks traditionally associated with human cognitive ability, such as the ability to learn and solve problems. It is an interdisciplinary approach using principles and devices from computing, mathematics, logic, mechanics and even biology to solve problems of understanding, modeling and replicating cognitive intelligence [4, 6, 7, 8].

Natural learning4 is a concept of great importance for building intelligent systems with learning capabilities. Thus, the ability to learn is directly linked to the following items:

• **Adaptation:** a biological or artificial system that is not capable of evolving or changing its behavior in the face of new situations presented to it does not constitute an intelligent system; 9

• **Error correction:** an intelligent system must modify its current behavior in order to satisfy some requirement;

• **Optimization:** improvement of the performance of the system as a whole, always meeting the project conditions[9].

• **Databases:** The system must be able to store a large amount of information to be used or employed according to the process needs [9].

There is a need for AI to add new knowledge to self-improvement by collecting data patterns that were not previously programmed. This machine learning enhancement capability is known as “Machine Learning”. This makes it possible for computers to perform complex procedures with broader knowledge [9].

"Machine Learning" is an area of Artificial Intelligence that gives computers the human ability to decipher and understand patterns through data previously added to the system. Processing data repeatedly, it becomes capable of creating new data by crossing patterns of previously obtained information. This fast-paced, purpose-built enhancement brings a huge advance to AI making it possible to perform tasks that were not possible before. Such progress is the reason that leads to the exploration of such an are [8, 10].

It is difficult for human beings to program machines, since it is not always possible to describe the resolution of problems, or diagnoses, performed intuitively or by aspects that generally do not seem to be correlated. But what takes time and a lot of effort for humans, it would not be such an exhausting and slow process if machines were programmed for this, such as issuing a medical diagnosis from an image [9].

Radiology is one of the areas that has stood out the most in the use of artificial intelligence. Chest x-rays are the most used medical imaging exams, reaching about 2 billion exams performed in the world annually. Deep convolutional neural networks (Deep CNNs) have been diagnosing pathology on radiographs as well as many radiologists who have taken part in the diagnostic comparison test, to assess whether AI would actually deliver diagnoses that are up to the standards of the radiologists themselves.11 With radiology, the advances are no different from those experienced in other areas, since there have been evolutions since 1985, when X-rays were discovered, until the present day, with the most varied techniques of digital radio diagnostics. Digital radiology is the branch of medical diagnosis that uses different methodologies applied by computational systems in order to acquire, transfer, store and treat radiographic images acquired from almost all modalities. This area has been experiencing major changes thanks to technological advances and imaging methods that emerged after conventional radiographs were replaced by digital radiographs, colour and multiplanar reconstructions in 2D and 3D, which has enabled much more accurate diagnoses for patients and decreases significant errors in radiographic findings [12, 13, 14].

With this wide range of images, Convolutional Neural Networks (CNNs) have become a great lever in AI due to their great ability to recognize and process images. CNNs have several layers of information processing that will analyze the images, mainly recognizing patterns, which requires a previously processed database for comparisons. They are composed of "neurons" that are automatically optimized by "Machine Learning", which each neuron layer will process, according to the programmed algorithms, the width, height and density of the pixels [8, 14, 15, 16, 17].

2. Artificial intelligence applied to radiology

FCNs (Fully convolutional network) made it possible to train models for pixel language with end-to-end segmentation. This made it possible, with the help of good GPU memories, to improve the reconstruction of 3D images of the organs located in the abdomen and thorax. This sample model achieves state-of-the-art performances in automated segmentation of multiple abdominal CT organs with an average of 90% of data tested across all organs targeted [18].

Researchers at the University of Science and Technology in Norway applied a filter to detect and locate nuclei in medical images. For this, they implemented and used a state-of-the-art method called "Mask R-CNN", which is a neural network developed for segmented image analysis, which proved capable of detecting stem cells in medical images [19].

3. Deep learning (DL)

To identify cell nuclei and fluorescent proteins, staining agents have been widely used. However, exogenous agents inevitably prevent long-term visualization of live cells and rapid analysis, and even interfere with intrinsic physiological conditions. Researchers from South Korea proposed a method of free segmentation of cell nucleus labels in optical diffraction tomography images, using a deep learning framework (Deep Learning or DL). The proposed method was applied for the precise segmentation of the cell nucleus in unlabeled images in two, three or four dimensions and aims to bring broad and immediate biomedical applications to clinical pictures analyzed by images [19, 20].

Researchers Rajpurkar P, et al. developed a deep learning algorithm to detect pathologies on chest X-rays and thus compare them with the pathologies found by radiologists. This neural network was called CheXNeXt, programmed to detect 14 different types of pathologies in conventional chest X-rays, and they found that this DL model detects the different pathologies present in the images as well as the radiologists themselves [21].

Japanese scientists have developed an AI using “Deep Learning” to improve the image acquired by computed tomography (CT) and magnetic resonance imaging (MRI). They categorized techniques to improve image quality as “noise and artifact reduction”, “super-resolution”, and “image acquisition and reconstruction”. The reduction of noise and artifacts helped to decrease radiation exposure in CT scans and to shorten the MRI (Magnetic Resonance Imaging) scan time. The super-resolution technique can optimize the diagnosis, improving the resolution of thick images and shortening the image acquisition time required for MRI exams, which is very beneficial to patients, regardless of the pathology [22].

3.1 Convolutional neural networks (CNNs) with deep learning

Some researchers have used convolutional neural networks (CNNs) to detect signs of pneumonia present in chest X-rays. , but also has the ability to process confusing information [16, 17, 23, 24, 25].

Fang Liu and his colleagues developed a deep learning neural network model using computed tomography images in order to minimize the flaws of images acquired by PET-MRI (Positron Emission Tomography - Imaging by Magnetic Resonance) and improve them, since magnetic resonance does not acquire good images of bone structures. They used 30 three-dimensional images to train the model, and thus, it was evaluated in 10 patients, comparing the images generated by the model with the acquired images. As a result, the images were reconstructed with less than 1% failure, unlike conventional image reconstruction approaches [26].

A deep learning method (Deep Learning) with a convolutional neural network (CNN) was used to investigate the diagnostic performance for differentiating liver masses on computed tomography (CT) with dynamic contrast. The retrospective clinical study used sets of CT images of liver masses over three phases (non-enhanced agent, arterial, and delayed). Masses were diagnosed according to five categories, ranging from cysts to carcinomas. Supervised training was performed using 55,536 image sets obtained in 2013. The CNN was composed of six convolutional layers, three maximal clusters and three fully connected layers. It was tested with 100 liver mass images obtained in 2016. Testing and training were performed five times. The accuracy for categorizing liver masses with the CNN model and the area under the ROC curve for differentiating AB versus CE categories were calculated. The study then concluded that deep learning with CNN showed high diagnostic performance in differentiating liver masses on dynamic CT [27].

Nicholas Bien and other researchers developed a deep learning neural network model to detect disturbances in magnetic resonance imaging (MRI) scans of the knee to improve diagnostic accuracy. The model predicted, in a matter of seconds, 3 test results including meniscal injuries and others. The model statistically helped orthopedic surgeons and radiologists diagnose knee scans by using internal and external datasets to quickly generate accurate classifications of clinical pathologies from knee MRI scans [28].

Researchers at Stanford University in California devised a system using deep learning algorithms to create deep learning convolutional neural networks (deep learning CNN or DNN) that could analyze clinical images and diagnose skin diseases and compare their performance in diagnosis with that of dermatologists. Unpublished images of biopsy-proven lesions were shown and dermatologists were asked whether they would: Take the biopsy, treat the lesion, or reassure the patient. CNN was trained on 129,450 accredited, biopsy-proven clinical images consisting of 2,030 different diseases. CNN performed at par with all experts tested in both tasks, demonstrating artificial intelligence capable of classifying skin cancer with a level of competence comparable to dermatologists. Deep learning CNN outperforms dermatologists in classifying skin cancer using dermoscopic imaging. Equipped with deep neural networks, Mobile devices can potentially extend dermatologists' out-of-office reach [16, 17, 29, 30, 31].

The use of deep learning neural networks for image classification, object detection, segmentation, registration and other tasks was the focus of researchers at the Redbud University Medical Centre in the Netherlands. In exam classification, you typically have one or several images (an exam) serving as the input model with a single diagnostic variable as the output (for example, disease present or not). Detecting objects of interest or lesions in images is a fundamental part of diagnosis and is one of the most intensive jobs for clinicians. Typically, tasks consist of locating and identifying small lesions within the full image space. Computer-assisted detection systems are designed to automatically identify lesions with high accuracy and decrease the reading time for human specialists [25, 30, 31, 32, 33].

3.2 Machine learning (ml) in imaging diagnosis of covid-19

Research published by Mohamed Abd Elaziz et al. proves that ML has demonstrated high performance for various image processing applications such as analysis, classification and segmentation. Several methods based on ML and DL were used to classify chest radiographs of COVID-19 positive and negative patients. The authors proposed a CNN model for the automatic diagnosis of COVID-19 from chest X-ray images. The reported classification accuracy is 96.78% using the Mobile Net architecture [42].

The method proposed by Mohamed et al. extracts features from chest X-ray images using the FrMEMs descriptor software, multichannel fractional exponents, employing the MRFODE algorithm that reduces/removes redundant and/or irrelevant data in the search and uses an image classifier known as KNN which, in turn, time, will identify and display images of interest, after training. 42 An illustration of the process can be seen in figure 1 below, where it is shown that at the end of the process the KNN classifier brings the positive and negative diagnosis for COVID-19.

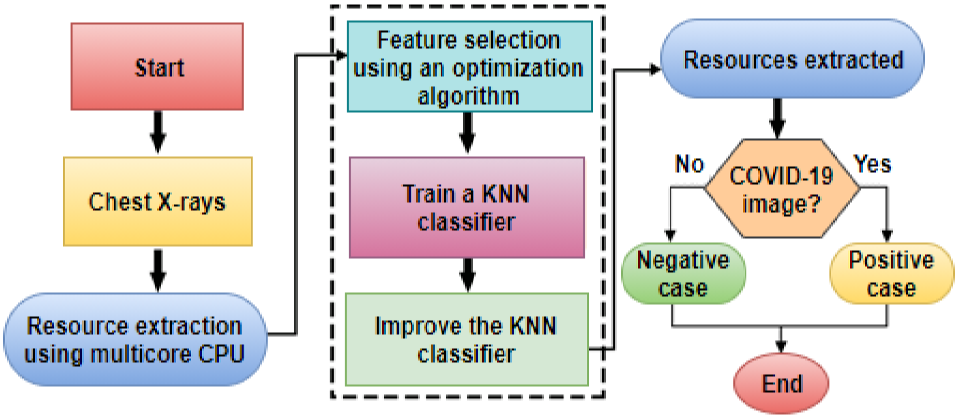

Figure 1. Flowchart of the method proposed by the authors.

To carry out the study, Mohamed et al. used two different datasets, where:

The first dataset collected by Joseph Paul Cohen, Paul Morrison and Lan Dao on GitHub contained images pulled from 43 different publications, with 216 COVID-19 positive images and 1,675 COVID-19 negative images [42, 43].

The second set of data used was collected from a team of researchers from the University of Qatar and the University of Dhaka, Bangladesh, along with their collaborators from Pakistan and Malaysia in collaboration with doctors and added images from the COVID-19 database. of the Italian Society of Medical and Interventional Radiology (SIRM). It is mentioned that this second dataset consisted of 219 positive COVID-19 images and 1341 negative COVID-19 images.

It is also mentioned that both sets of data used are images of COVID-19 collected in patients aged between 40 and 84 years for both sexes [42, 44, 45].

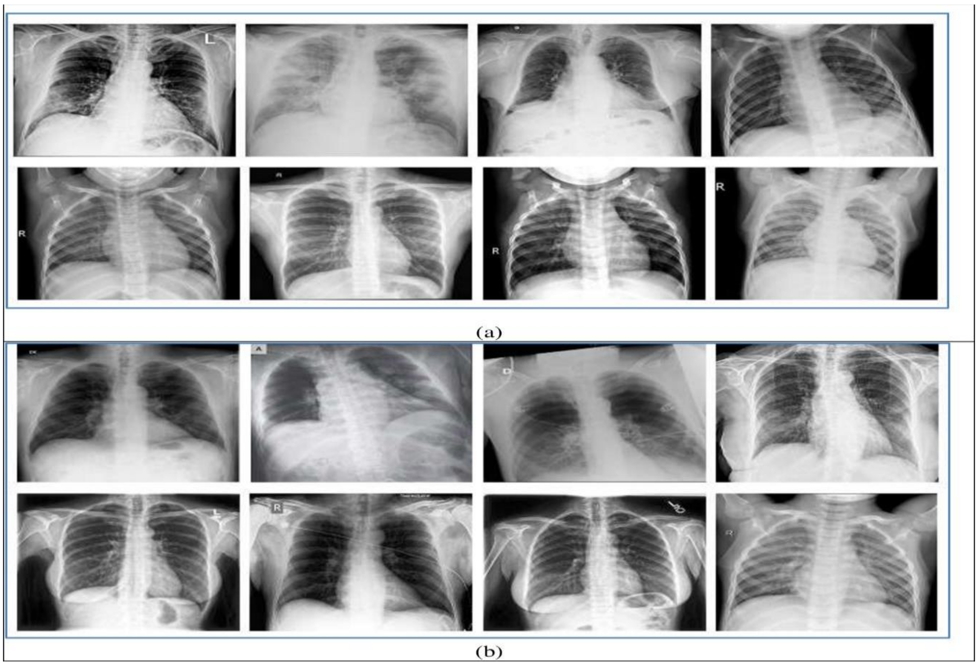

Figure 2. Sample images: (a) first set of data; (b) second set of data.

The method proposed by Mohamed et al. obtained high performance in the metrics of accuracy, recall and precision evaluation with fewer resources when compared to other methods42. It is also mentioned that the right to use the images in Figure 2 was granted by their authors during this research.

3.3 Changes and forecasts

As a more specific example of using AI for diagnostic imaging, primarily using deep learning CNNs, Google Inc. and Google Brain (Deep Learning Artificial Intelligence Research Team at Google), in partnership with the company Verily Life Sciences, have developed an artificial intelligence capable of detect cancer metas tases in gig pixel pathology images, reducing the false positive rate to a quarter of a pathologist's rate. The authors state that this method can improve the accuracy and consistency in the evaluation of breast cancer cases and potentially improve patient outcomes [34].

The Canadian Association of Radiologists White Paper predicts that the implementation of AI in radiology over the next decade will significantly improve the quality, value, and depth of radiology's contribution to patient care and population health. , and will revolutionize radiologists' workflows [6].

Radiology has already experienced major changes in the market due to technological advances, and artificial intelligence is increasingly on the rise. The shorter the time to report exams directly implies an increase in the time that the professional will have to pay attention and segment to the patient's diagnosis, which becomes a great advance in the health area, because the faster a diagnosis, the more chances can be be found for early treatment. Thus, it is up to professionals to commit themselves to trying to understand how AI works [22, 33, 35, 36, 37].

This work aims to verify, through a thorough bibliographical study, the current presence of artificial intelligence applied to the optimization of diagnostic imaging, showing its efficiency in several tasks, in order to awaken professionals in the area about the evolution of technology to obtain a better and faster medical diagnosis, which may require them to adapt to their insertion or permanence in the labor market.

4. Methodology

The work developed followed the precepts of the exploratory study, through a bibliographical research that, according to Gil, is developed from already prepared material, consisting of books and scientific articles.38

In this perspective, Gil's proposal (2008) was used in the following steps:

The sources that provided the appropriate answers to the solution of the proposed problem are described below:

Books, divided into the areas of radiology and informatics, clinical radiology books and other technical books that address the subject, in Portuguese and English, available in the UNOESTE library, published from 2010 to 2020.

Scientific articles on the subject accessed in the Scielo, Plos One, CONTER, MEDLINE, MY LIBRARY databases, published in the last 10 years (2010 to 2020).

Monographs available in the radiology course library at Unoeste published in the same period.

Data collection followed the following premise:

A) Exploratory reading of all selected material (quick reading that aims to verify whether the work consulted is of interest to the work);
B) Selective reading (deeper reading of the parts that really matter);

C) Registration of information extracted from sources in a specific instrument (authors, year, method, results and conclusions).

5. Results

The objective of this study was to present the presence and importance of artificial intelligence applied in the medical area of diagnostic imaging in the world scenario, through a current bibliographical review.
In general, AI has shown promising results when it comes to diagnostic analysis compared to human professionals. Most comparative tests of diagnostic quality between AI and radiologists have stated that it is equally or slightly better at detecting radiographic findings, rarely losing out to professionals when it comes to image analysis.
Artificial intelligence has accelerated imaging diagnosis and has been widely used for comparative diagnoses, eliminating diagnostic doubts.

6. Conclusion

According to the analysis of the research, medicine is being impacted by AI on three levels: for physicians, predominantly through fast and accurate image interpretation; for healthcare systems, improving workflow and potentially reducing medical errors; and for patients, enabling them to process their own data to promote health 8, 11, 25.
Technological evolution in diagnostic imaging is accelerating. Technological knowledge is necessary to handle the new supports (both hardware and software) that are being updated to optimize exams and diagnoses.
As AI can perform highly complex tasks on its own, it is possible that there will be a revolution in the workflows of radiologists. This revolution, being technological, can make it difficult for professionals to stay and determine the entry of professionals into the job market.
As Omir Antunes Paiva mentions in his article, the software will provide data that, generally, it is not possible to be extracted by human professionals, will automatically prioritize the exams according to the severity, among other resources, which can be mentioned, minimization of flaws in the images, reconstruction, improvement, reduction of noise and artifacts of the acquired images, which are corroborations of researchers such as Toru Higaki and Fang Liu.[22, 26, 35].
All concepts discussed here are also complemented by Dr. Michael Forstin, who claims that artificial intelligence will take over mundane jobs like determining ventricular size after miscarriage, measuring liver metastases during treatment, assessing bone age in the hand, and measuring angles in scoliosis. As it will only be necessary to train the algorithms to reliably detect the target organ and the lesion [39].
The United Nations (UN) noted that when human diagnosis is accompanied by AI, the error rate decreased to 0.5%, versus 3.5% for human doctors. Recent studies have also shown that the combination of human clinicians and AI produces better results than either alone [40].
Thus, the various benefits arising from artificial intelligence in diagnostic imaging are undeniable due to its great capacity for image processing and pattern recognition. Computational evolution, both in terms of “software” and “hardware” in the medical field, has allowed diagnostic imaging to achieve enormous qualitative and quantitative progress.
In this way, it is evident that AI can become essential for diagnostic imaging and the need for professionals for simple and routine tasks may decline in the years to come, due to the fact that artificial intelligences are already

being trained, corrected and improved, and the point will come when all these activities can finally be performed without direct human intervention, revolutionizing the diagnostic sector [41].

However, a self-respecting artificial intelligence needs a large database and computers with powerful processors for better functioning. Algorithms must be tested for a long time to prove their excellence. In short, the machinery is expensive and it takes a lot of time to test and feed selected information to the AI.

It is concluded that the attributions of artificial intelligence, mainly through the use of CNNs, should help radiologists to achieve excellence in medical diagnosis. This area will have to adapt to the numerous changes that AI will make possible in the coming years, in order to benefit the diagnosis and care of patients. Therefore, professionals versed in radiology who know how to use technology to their advantage will clearly have advantages over those who do not seek to integrate with it.

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