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Image Reconstruction for Ultrasound Imaging: An Assessment

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ABSTRACT

In order to guide illness diagnosis and therapy, ultrasound imaging is essential in today's clinics. Obtaining high-quality ultrasound pictures for clinical use at the lowest possible cost and patient risk is the main goal of ultrasound image reconstruction, one of the most essential and crucial aspects of ultrasound imaging. In ultrasound image reconstruction, or more broadly in computer vision picture restoration, mathematical models have been heavily used. Earlier mathematical models—which we will refer to as handmade models—were primarily created using human knowledge or conjecture about the picture that needed to be recreated. Later, data-driven plus handmade modelling began to take shape, while it still largely depends on human designs; some of the model's knowledge is derived from the observed data. Recently, deep learning-based models, also known as deep models, have pushed data-driven modelling to the limit where the models are mostly dependent on learning with little to no human design, thanks to the increased availability of data and computing power. There are benefits and drawbacks to both data-driven and handmade modelling. Though they may not be adaptable and smart enough to fully use huge data sets, typical handmade models are easily interpreted and have strong theoretical underpinnings for robustness, recoverability, complexity, etc. On the other hand, while they still lack theoretical underpinnings, data-driven models—especially deep models—are often much more adaptable and successful in obtaining valuable information from massive data sets. In order to reap the advantages of both methods, combining deep modelling with handmade modelling is one of the main research topics in medical imaging. This article primarily presents a conceptual assessment of some recent research on deep modelling from the perspective of unrolling dynamics. From this perspective, new neural network architectural ideas are stimulated, drawing inspiration from numerical differential equations and optimization methods. Despite the widespread use of deep modelling, there are still many unmet potential and problems in the subject, which we will cover in our article's conclusion.

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I. INTRODUCTION

Medical imaging modalities have been used to view body parts, organs, and other tissues. These modalities include computed tomography (CT), magnetic resonance imaging (MRI), X-ray, and ultrasound. However, in addition to picture artefacts, images obtained using these imaging modalities may have poor signal-to-noise ratios (SNR) and low contrast-to-noise ratios (CNR). Techniques for image reconstruction have been created to get around these issues and enhance picture quality for more accurate visual interpretation, comprehension, and analysis.

Medical imaging applications of deep learning (DL) methods include radionics, computer-aided detection and diagnosis, and medical image analysis. In the recent past, deep learning—also known as representation learning—has garnered a lot of interest for medical image analysis. Because deep learning can learn features from raw input data during training, it is considerably superior than typical machine learning techniques. It can learn abstractions from inputs thanks to its many hidden layers. Deep learning is being used and used in many disciplines, including medical picture reconstruction, because to recent advancements in effective computational infrastructures like cloud computing systems and graphics processing units (GPUs).

The process of creating a picture from measurements is called image reconstruction. Sensor encoding, or the representation of an object in the sensor domain that is subsequently transformed into an image by inverting the encoding function, is a step in the image reconstruction process. Due to the possibility of a priori lack of analytical information about the precise inverse transform, image reconstruction is a difficult operation, particularly when noise and non-idealities in the sensors are present. The shortcomings of conventional picture reconstruction methods stem from the inability to constantly know the precise inverse transform. Additionally, they call for the use of approximations made by a series of finely calibrated signal processing modules, which may be problematic, particularly when dealing with genuine, noisy data. The method of reconstructing images will be completely transformed by deep learning algorithms. Furthermore, medical picture reconstruction is now faster, more accurate, and more resilient thanks to deep learning-based methods.

The main goal of this study is to review the current applications of deep learning in medical imaging, in particular for medical image reconstruction. We focused on open science medical imaging research, the currently available open imaging data sets for deep learning, and also on the open-source software packages that are available for medical image processing. A lot of research has been done that explains in detail the deep learning techniques and their applications; however, there is a scarcity of research publications that provide a review of the applications of deep learning in medical image reconstruction. The study gives an extensive review of deep learning in medical image reconstruction but the paper focuses more on the mathematical models of several deep learning algorithms in medical image reconstruction.

II. PREVIOUS WORK

Because ultrafast ultrasound (US) can acquire full-view frames at a frequency of more than 1 kHz, it has revolution is used bio-medical imaging and made breakthrough modalities like shear-wave elastography and functional US brain imaging possible. Comprehensive numerical analyses show that, over a dynamic range above 60 dB, the suggested method can reconstruct pictures from single PWs with a quality comparable to gold-standard synthetic aperture imaging. Trainings conducted on simulated data function well in experimental situations, as shown by both in vitro and in vivo tests [1].

In the area of medical imaging, including computer-aided diagnosis (CAD), radiomics, and medical image analysis, the use of machine learning (ML) has been growing quickly. There are a number of parallels and variations between the two main models in this class of machine learning for medical imaging, CNN and MTANN. We found that MTANNs performed better, needed fewer training instances, and were much more efficient in their development than CNNs. "Deep learning," or machine learning using image input, is a rapidly expanding and exciting topic in medical imaging. In the next decades, machine learning using image input is anticipated to become the dominant field in medical imaging [2].

Medical imaging research requires the use of machine learning algorithms. Deep learning, a highly flexible machine learning strategy, has recently surfaced as a disruptive technology to improve the performance of current machine learning approaches and tackle issues that were previously unsolvable. One of the main areas of study where deep learning may make a substantial contribution is medical imaging. The purpose of this review paper is to outline the possibilities for deep learning in medical imaging research going forward. First, a summary of the development of deep learning from classical machine learning is given. The second section provides an overview of deep learning's use in medical imaging research. Third, well-known deep learning software tools are examined. Lastly, limitations are noted along with future prospects for deep learning in medical imaging [3].

This article provides a thorough overview of past and contemporary state-of-the-art methods in natural language processing, social network analysis, and the processing of images, sounds, and texts. It then delves further into pivotal and revolutionary developments in deep learning applications. It was also attempted to discuss the problems with deep learning, including online learning, black-box models, and unsupervised learning, and to show how these problems might be turned into fruitful directions for future study [4].

A key component of computer-aided diagnosis and prognosis is image analysis for microscopy. Numerous facets of clinical practice and medical research have benefited from the use of machine learning methods. Specifically, we analyze their formulations or modeling for distinct tasks on different microscope pictures, and we describe the architectures and principles of convolutional neural networks, fully convolutional networks, recurrent neural networks, stacking autoencoders, and deep belief networks. Furthermore, we talk about the unresolved issues and possible directions for further deep learning-based microscope image processing research [5].

This review discusses the use of deep learning in medical diagnosis. A comprehensive review of several scientific publications about the use of deep neural networks in medicine has been carried out. Furthermore, it can be seen, based on the results of this study, that deep learning technology is widely used, with the bulk of these applications concentrated in the disciplines of bioinformatics, medical diagnostics, and other related ones [6].

III. PROBLEM IDENTIFICATION

Following are the problem identification on the basis of existing work:

- The identification of proper image reconstruction is low.
- The quality of image reconstruction not preserved.
- The image reconstruction is slightly similar to original image.

IV. OBJECTIVES

Following are the objectives of the proposed work:

- To reduce MSE for proper identification of image reconstruction.
- To improve PSNR for preserve quality of image reconstruction.
- To improve SSIM for enhance similarity in between of original image and constructive image.

V. PROPOSED METHODOLOGY

The Algorithm of proposed methodology RNN-ReLU (Recurrent Neural Network with Rectified Linear Unit) is as follows

The Recurrent Neural Network consists of multiple fixed activation function units, one for each time step. Each unit has an internal state which is called the hidden state of the unit. This hidden state signifies the past knowledge that the network currently holds at a given time step. This hidden state is updated at every time step to signify the change in the knowledge of the network about the past. The hidden state is updated using the following recurrence relation:

The formula for calculating the current state:

$$h_t = f(h_{t-1}, x_t)$$

where:

h_t -> current state

h_{t-1} -> previous state

x_t -> input state

Formula for applying Activation function (ReLU):

$g(h_t) = \max(0 , h_t)$

Training through RNN

1. A single-time step of the input is provided to the network.
2. Then calculate its current state using a set of current input and the previous state.
3. The current ht becomes ht-1 for the next time step.
4. One can go as many time steps according to the problem and join the information from all the previous states.
5. Once all the time steps are completed the final current state is used to calculate the output.
6. The output is then compared to the actual output i.e the target output and the error is generated.
7. The error is then back-propagated to the network to update the weights and hence the network (RNN) is trained using Backpropagation through time.

VI. EXPECTED CONCLUSIONS

We examined the most recent research on deep learning's use in ultrasound image reconstruction throughout this investigation. It was said that deep learning gained popularity in 2012 because a method based on deep learning decisively defeated competitors in computer vision. It was also discovered that, in contrast to conventional machine learning algorithms, which call for human involvement, deep learning automatically extracts characteristics from the training datasets. Our research demonstrates the effective use of deep learning methods to picture reconstruction. They may contribute to a reduction in imaging time by quickening the data collecting process. Comparing results from ultrasonic imaging systems to analytical, iterative, and compressed sensing-based approaches showed improvements in picture quality and effective noise reduction.

Classification, segmentation, and registration are among the various medical image processing tasks for which deep learning has been effectively used. The examined literature also demonstrates that deep learning approaches need a lot of training datasets, are computationally costly, still require theoretical analysis to understand why the algorithms function, and that problems with generalization and robustness of deep learning techniques need to be resolved. Furthermore, the dependability of deep-learning systems raises questions when they are employed without radiologist oversight. As a result, it is unclear who is responsible for errors or disinformation that endangers patients.

By using the recommended method, you may lower the mean square error (MSE) for precise identification of image reconstruction. Improve SSIM to make the original and constructive pictures more comparable, and raise PSNR to keep the reconstruction quality of the image high.

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