Chapter 80
Implementation and Performance Assessment of Biomedical Image Compression and Reconstruction Algorithms for Telemedicine Applications:
Compressive Sensing for Biomedical Images

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ABSTRACT

Compression serves as a significant feature for efficient storage and transmission of medical, satellite, and natural images. Transmission speed is a key challenge in transmitting a large amount of data especially for magnetic resonance imaging and computed tomography scan images. Compressive sensing is an optimization-based option to acquire sparse signal using sub-Nyquist criteria exploiting only the signal of interest. This chapter explores compressive sensing for correct sensing, acquisition, and reconstruction of clinical images. In this chapter, distinctive overall performance metrics like peak signal to noise ratio, root mean square error, structural similarity index, compression ratio, etc. are assessed for medical image evaluation by utilizing best three reconstruction algorithms: basic pursuit, least square, and orthogonal matching pursuit. Basic pursuit establishes a well-renowned reconstruction method among the examined recovery techniques. At distinct measurement samples, on increasing the number of measurement samples, PSNR increases significantly and RMSE decreases.

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INTRODUCTION

With the advancement in information and communication technology, data traffic generates noticeably massive amount of information data especially in biomedical area. Radiological medical imaging methods (MRI and CT-Scan experiments) are used to inspect and analyze the inner structure of human body. These methods generate a large amount of scientific information which is digitally stored in the form of medical image that can be easily accessible. Clinical imaging records are significantly high as a typical hospital generates terabytes of information per year (Ravishankar & Breler, 2011). Clinical imaging data is certainly excessive and needs more storage space thus medical image compression is essential. Compression is a proficient solution for illustrating compact and robust data representation to facilitate efficient transmission and storage. File size is reduced, less bandwidth is utilized and the transmission speed is accelerated using compression techniques. Predominant goal of compression is to lessen the redundant and irrelevant bits of data for efficient data storage and transmission. Compression may be extensively categorised into two classes, Lossy and Lossless Compression. Lossy compression is appropriate for the applications where a slight loss of information is permissible like for natural pictures, text images, etc. For lossy compression techniques, compression ratio is high but the image quality is low. In case of lossless compression, the reconstructed image is the exact replica of the actual image as there is no data loss in lossless compression technique. Compression ratio achieved for this approach is not always high but the recovered image is of better-quality as compared to that of the lossy compression approach.

Data loss is not tolerable in scientific field like biomedical image processing as it can lead to wrong diagnosis. Many hospitals have small clinics situated in the far flung regions where distance is a vital issue to deliver the health care facilities. Patient residing in remote, rural and semi-urban areas find tough time to travel to far away hospitals particularly for diagnostic functions. For the convenience of patients suffering from severe diseases, the hospitals make use of telemedicine practices to provide health care facilitates in such areas. These tele-radiology applications allow the technician at the remote centres to capture a series of medical image data (MRI or CT scan) and transmit it to the principal health centre situated at the city where the diagnostic radiologist can examine the image and send back the diagnostic information to the clinical prognosis and the patients (Vijaykuymar, & Anuja, 2012).

In conventional image capturing systems, sampling is primarily based on Nyquist criteria wherein the original signal is sampled at a rate more than or equal to two times the maximum frequency of the signal. This sampling rate is too high for certain applications thereby increasing the complications in terms of complexity during compression. The increased rate of sampling adds directly to the complexity of the sensing hardware and this leads to wastage of power resources (Zhao, *et al*., 2017; Wiegand, *et al*., 2003). So, to facilitate the need of image compression for contemporary applications it is required to have a system with decreased acquisition complexity and flexible process for decoding. Compressive Sensing (CS) technique emerges as a new idea for signal acquisition, compression and reconstruction which has become main focus of researcher's interest. It is a far unique technique employing sub-Nyquist sampling criteria overcoming the drawbacks of the conventional strategies (Donoho, 2006; Candes, *et al*., 2008; Romberg, *et al*., 2006). CS utilizes the sparse signal recovery using fewer linear measurements and convex optimization approach for approximate recovery relative to standard schemes utilizing the complete ensemble of signal space (Candes & Romberg, 2007).

The concept of CS was at first introduced by Emmanuel Candes, collectively with Justin Romberg and Terry Tao (Donoho, 2006; Candes, *et al*., 2008; Romberg, *et al*., 2006; Candes, *et al*., 2007). Signals fulfilling the requirement of sparsity in any domain can be recovered using CS approach, may it be an

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