Fast Compression For Brain Mr Images With Proposed Algorithms

M.Ramanjaneyulu, A.V.Narasimha Rao, M.Balraju

Abstract: Growth in information storage and retrieval significantly depend on images in various domains as the information representation and understand ability is significantly higher. The challenges in processing the complete information in image formats are obtained during storage and transmission. Also, the information extractions from images are significantly difficult compared to information extractions from text. Nonetheless, the incorporation of image analysis for disease detection involves gigantic amount of image data storage, which is a concern of financial drawbacks. Hence, the images used for the analysis must be compressed for storage. However, the complexity of image compression is critical as the information loss can cause significant difference in disease detections. Thus the traditional lossy image compression methods cannot be applied to this problem. Hence, this work addresses the optimal compression of the medical images without vital information loss and with ominously high compression ratio as the second objective of this work.

Keywords: Medical Image Compression, Lossless, Lossy, Segmentation, Fast Compression

I. INTRODUCTION

With the enhancements in medical imaging, the diagnosis and manual detection of the diseases are very successful now as days. The popular medical imaging techniques are Computed Tomography, Magnetic Resonance Imaging, Electronic-Endoscopy and many others. The computing technologies deployed in these methods helps to improve the detection accuracy of the diseases. The medical imaging techniques are classified into three major classes as structural-imaging, functional-imaging and molecular-imaging techniques. A good number of research contributions were made towards these research objectives. The recent notable outcomes by A. Souza et al. [1] on volume rendering of the medical imaging techniques, intensity standardization on medical imaging by A. Madabhushi et al. [2] and the work by Y. Zhan et al. [3] on three dimensional medical image segmentations have opened newer thoughts and research dimensions.

Considering the recent improvements in research, a wide variety of algorithms got developed as an outcome of several practices. The notable outcomes by W. Schroeder et al. [4] for medical data visualization, W. J. Schroeder et al. [5] for enhancements in visual analysis of medical information and further three dimensional visualization of medical imaging made possible by W. J. Schroeder et al. [6] have showcased the benefits of image based representations of the medical information. Also, the contributions by L. Ibanez et al. [7] for the ITK tool cannot be neglected. Nonetheless, the image cannot be left to manual interpretation for diagnosis and detection of the diseases. Hence the computation of Algorithm is based on the tools which must be developed. The work of J. Udupa et al. [8] for analysis of the medical images was the entry point to this field of research. Motivated by the possibility exploration for automated analysis for medical domain, the I. Wolf et al. [9] and Kitware group [10] made the interactive medical image analysis possible.

In the recent time, among all the medical imaging techniques the MR images became widely accepted. The acceptance have motivated various researchers to focus on medical image analysis for multiple purposes as J. Tian et al. [11], Y. Lv et al. [12] and J. Xue et al. [13] have contributed in founding the road map for further research by proving many analysis techniques on MR images [Fig – 1].

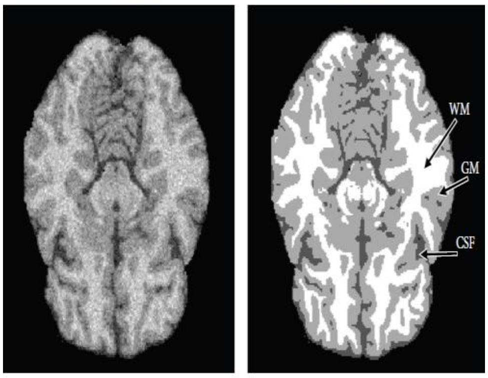

Fig. 1 MR Image Analysis for Human Brain

As final outcome of this work, a framework for providing optimal storage of MR images by using new compression method without losing valuable information is proposed.

II. OUTCOMES FROM THE PARALLEL RESEARCHES

In this section of the work, the recent outcomes in terms of image analysis image compression methods are evaluated for medical purposes. The notable outcome produced in the work by Lin Yuan et al. [14] has demonstrated a novel technique for extracting and safeguarding a medical image called JPEG trans-morphing. Further, the work of S.Vijayarani et al. [15] has demonstrated the image class detection methods for medical image classification.

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In the domain of DNA analysis by using medical images are also highly accepted, the work by Biji C.L. et al. [16] has contributed significantly for pattern analysis. Also, by analysing the depth of an object in a medical image can help in detecting the severity of some diseases as proven by Sorabh Khire et al. [17].

In the other hand the popular image analysis techniques also includes hiding and extracting information inside an image. Rina Mishra et al. [18] have demonstrated the benefits of information embedding and extraction from medical images.

Many of the times, the image contains noises due to the defect in the image accusation process. Thus removing the noises from the images are a mandatory task for obtaining higher and better accuracy for medical information analysis. The work by Ronald Marsh et al. [19] has demonstrated the most recent advancements in order to achieve the benefits [Fig -2].

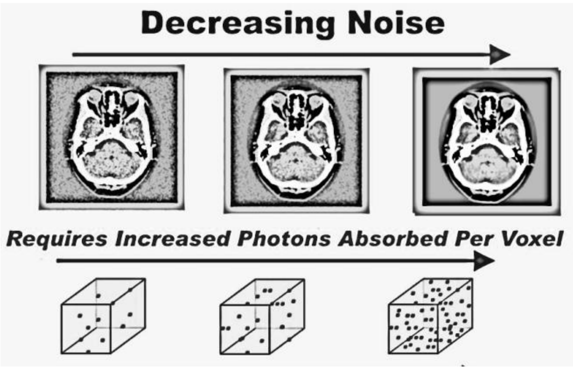

Fig. 2: MR Images and Effects of Noise

Looking at the recent and remarkable advancements in this field of study and research, the majority of the research focuses can be observed in analysing the important information available in medical images. This reduces the total image analysis time complexity in-spite of the initial high time complexity for extracting the principle components as elaborated by Ravi Kiran et al. [20].

Finally, medical image accusation and processing comes under the bioinformatics and understanding the generic process or the framework for bioinformatics is the first expectation to continue the research as this work. Thus, this work realizes the outcomes of the work by Masaya Moriyama et al. [21] on medical image sampling. Henceforth, with the knowledge of the recent research outcomes, this work formulates the problem in the next section

III. PROBLEM FORMULATION

The major objective proposed to be achieved in this work is to provide a lossless and high compression ratio for the MR images. The major challenge in compressing the medical image is the higher compression ratio will influence the high data loss from the image, which is the least expected outcome of medical image compression. Hence it is expected to reduce the information loss to zero and in-spite of the high information availability in the images, the compression ratio must be high.

Firstly, considering any image pixel, the amount of information can be assumed as follows:

$$P_i = \sum_{-\Delta j}^{+\Delta j} Info_j \quad \text{(Eq. 1)}$$

Here, P_i denotes any pixel in the image $Info_j$ denotes collective information in the pixel area.

Also, for each region of the images, the number of pixels available must be same. However, the amount of information available may not be same.

In order to realise the above statement, the following formulation is considered.

$$\mathrm{Re}\,g_k = \sum_i P_i \quad \text{(Eq. 2)}$$

And Subsequently,

$$= \sum_i \sum_{-\Delta ij}^{+\Delta ij} Info_{ij} \quad \text{(Eq. 3)}$$

Where, Reg_k denotes any region of the image

Thus based on the above assumption, the following realization can be considered as,

$$\mathrm{Re}\,g_k = \Psi Info_1 \ and \ \mathrm{Re}\,g_m = \Psi Info_2 \quad \text{(Eq. 4)}$$

Here, Reg_k and Reg_m denotes two different regions

Info1 and Info2 denotes the information density of both regions respectively

Also,

$$\mathrm{Re}\,g_k = \mathrm{Re}\,g_m \ but \ \Psi Info_1 \neq \Psi Info_2 \ , and \ \Psi Info_1 > \Psi Info_2 \quad (5)$$

Hence, in order to achieve the better compression on the medical, the algorithm must process both the regions separately and provide high compression on Reg_m and low compression on Reg_k regions. This will certainly help in achieving the objective. Thus separation of the image segments based on information availability will certainly solve the problem.

IV. PROPOSED FRAMEWORK

Proper identification of the problem helps the proposed framework to build. In this section of the work, the proposed framework is elaborated with the process flow [Fig – 3].

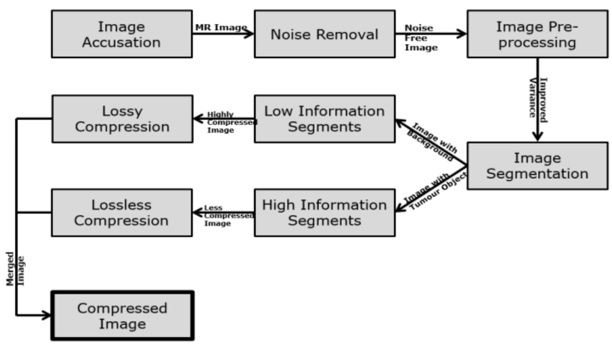

Fig. 3 Proposed Framework & Process Flow

As proposed the framework delivers two distinct outcomes. Firstly, the MR images are acquired from the MR image dataset, which is again collected from the BRATs dataset [23].

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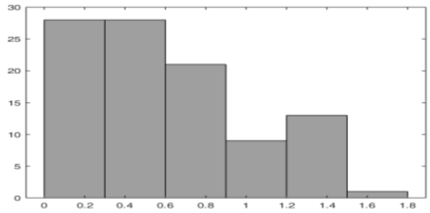
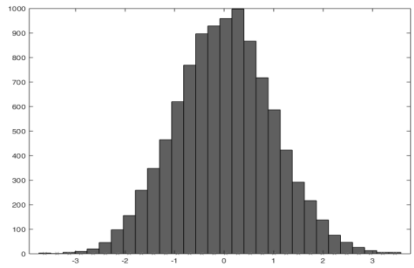
Further, the images are processed to identify and remove the noises available in the images. This process helps in improving the accuracy of the detection and highly compressed lossless set of images.

The images upon analysing for histograms may show different trends on the factor of normalization. For many of the images, the analysis becomes highly difficult due to the un-normal nature of the distribution of pixel values or the present of high variance. Thus in this phase of the work, the image variance are normalized. The results can be visualized here [Fig – 4].



(a)



(b)

Fig. 4 (a) Before Normalization – Highly Variant, (b) After Normalization – Less Variant

In continuation to the framework flow, the pre-processing image is further segmented. The segmentation technique used in this work is the modified watershed method, which is again elaborated in the further section of the work. The result can be visualized here [Fig – 5].

Fig. 5 MR Image after Segment Identification

The image segment with the red boundary is the identified region with higher information availability, thus this segment is processed with less compression and the remaining segments can be compressed with high compression ratio.

Once the image segments are compressed separately and the tumour region is also detected, the compressed images are merged again and stored.

V. PROPOSED COMPRESSION METHOD

In this section of the work, the proposed compression algorithm is elaborated.

Algorithm I: Proposed Compression Algorithm

Step-1. Accept the MR Image
Step-2. Apply segmentation method for the complete image
Step-3. For all segments in the image
  a. Analyse the pixel density
  b. Calculate the density of the information
  c. If density of the information > threshold
    i. Then classify the image as highly informative
  d. Else
    i. Classify the image as less informative
Step-4. For all highly informative images and all less informative images
  a. Perform the lossless compression
  b. Perform the lossy compression
  c. Merge the images
  d. Produce the final compressed image

This method is visualized here [Fig – 6].

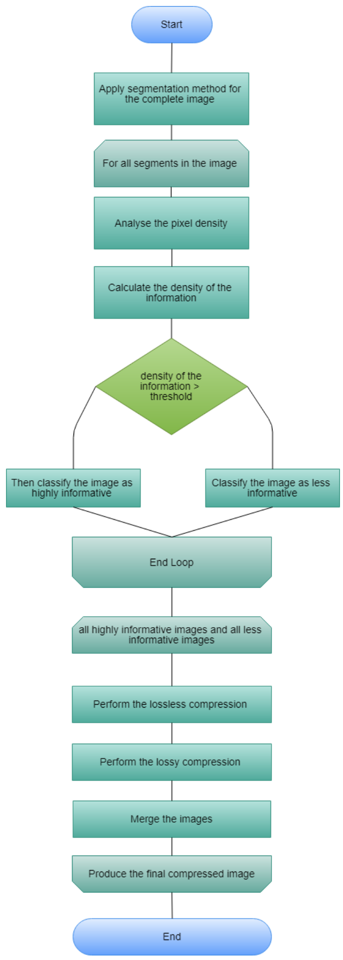


Fig. 6 Proposed Compression Method

This method preserves the information as high as possible and at the same time compress the images as best as possible

VI. COMPARATIVE ANALYSIS

In this section of the work, the proposed framework is compared with the parallel and recent outcomes of the researches for establishing the improvements achieved in this work. The comparative analysis is carried out on framework complexity, time complexity and stability of the models.

A. Framework Complexity Benefits

Firstly, the complexity of the proposed model is compared with the existing models in order to realize the practical possibilities to deploy the proposed model by replacing the existing models [Table – 1].

TABLE I
Framework Complexity Benefits Comparison

Model Name	Framework Complexity	Number of Benefits
VTK [5]	Only Visualization	1
ITK [7]	Visualization and Segmentation	2
MITK [24]	Visualization and Structure Analysis	2
Optimal [25]	Segmentation and Analysis	2
Proposed Method	Visualization, Segmentation, Analysis and Compression	4

The benefits are analysed visually [Fig – 7].

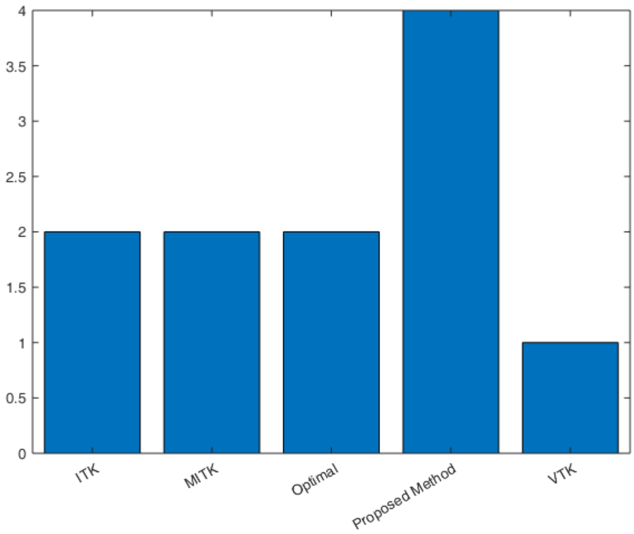


Fig. 7 Framework Analysis

Thus, it is natural to understand that the proposed framework provides the highest number of features.

B. Time Complexity Benefits

Secondly, the time complexity analysis is been compared [Table – 2].

TABLE II
Time Complexity Comparison

Model Name	Time to Complete the Process (Sec)
VTK [5]	3.6
ITK [7]	5.1
MITK [24]	2.8
Optimal [25]	1.5
Proposed Method	2.1

The benefits are analysed visually [Fig – 8].

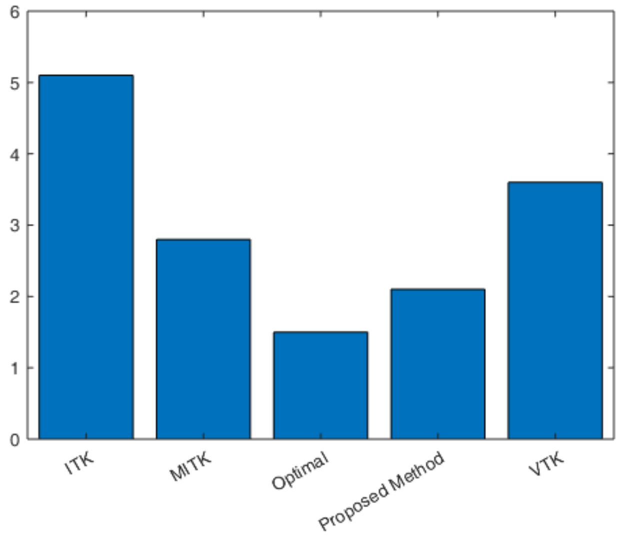


Fig. 8 Time Complexity Analysis

Hence, it is natural to realize that the proposed framework takes higher time to build the model compared to only Optimal [25] framework. It is also important to understand that the features provided by the Optimal [25] framework is half of the features provided by proposed framework.

C. Stability of the Model

Finally, the stability of the models is to be analysed. It is simple to understand that the underlying programming language is the key factor for deciding the stability of the model. The object oriented programming languages are less stable than the native programming models. The analysis is presented here [Table – 3].

TABLE III
STABILITY ANALYSIS

Model Name	Programming Language	Stability Ranking (As low as good)
VTK [5]	C++	2
ITK [7]	C++	2
MITK [24]	C++	2
Optimal [25]	MatLab	1
Proposed Method	MatLab	1

The result is visualized here [Fig – 9].

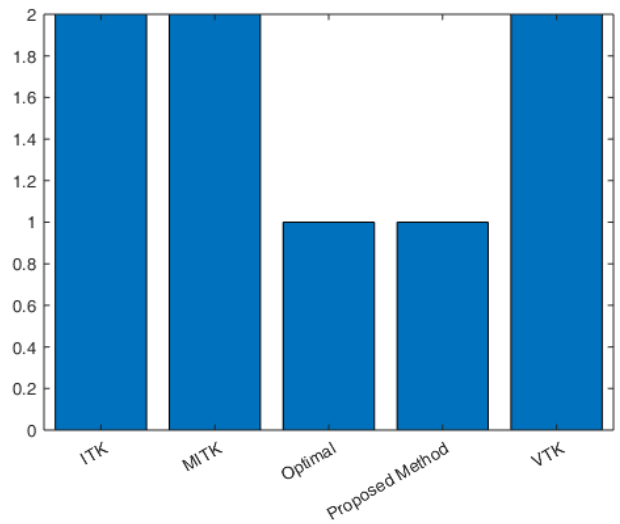


Fig. 9 Stability Analysis

Regardless to mention the proposed method is stable than the other popular methods.

Furthermore, in the next section of this work, the obtained results are furnished and discussed

VII. RESULTS AND DISCUSSION

This section of the work discusses the results obtained from three different phases of the proposed framework or the method.

D. Variance Normalisation

Firstly, the improvements in the variance is analysed for the dataset items [Table – 4]. The benefits of improving variance are already explained in the previous section of this work.

TABLE IV
Variance Improvements

Dataset Item	Actual Image Variance (Micrometre)	Filtered Image Variance (Micrometre)	Improvement (%)
Dataset Item - 1	2.9E+06	5.4E+06	87.7824
Dataset Item - 2	3.3E+06	3.3E+06	0.3724
Dataset Item - 3	8.0E+06	9.2E+06	15.7513
Dataset Item - 4	4.4E+06	4.9E+06	13.0526
Dataset Item - 5	1.8E+07	2.0E+07	11.4199
Dataset Item - 6	1.4E+07	1.5E+07	8.2627
Dataset Item - 7	2.3E+07	2.5E+07	8.3923
Dataset Item - 8	2.2E+07	2.4E+07	10.8011
Dataset Item - 9	1.0E+06	6.5E+06	549.0132
Dataset Item - 10	1.8E+06	5.0E+06	175.1102
Dataset Item - 11	3.6E+06	1.0E+07	180.3176
Dataset Item - 12	6.0E+05	4.4E+06	644.3848
Dataset Item - 13	1.7E+06	2.1E+06	19.7231
Dataset Item - 14	5.1E+06	8.3E+06	64.4621
Dataset Item - 15	5.1E+06	8.3E+06	64.4621
Dataset Item – 16	6.1E+06	6.2E+06	1.0669

The results are analysed graphically here [Fig – 10].

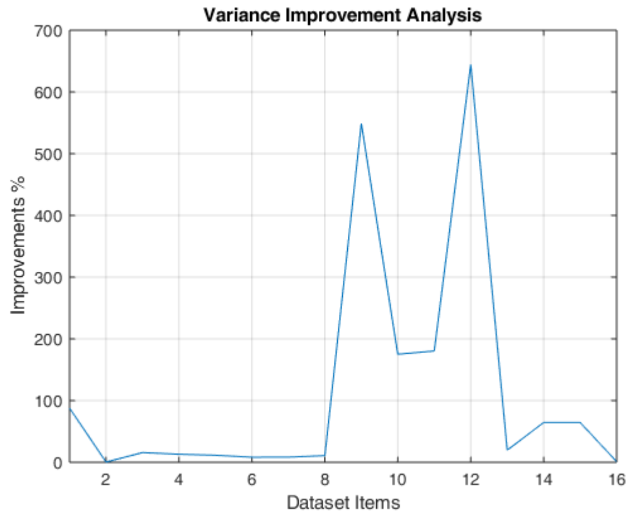


Fig. 10 Variance Improvements

Hence, it is natural to understand that the improvements of the variance of majority of the images are very high and these improvements are positively responsible for the accuracy improvements.

E. Compression of the Images

Secondly, the compression of the images is considered. It is to remember that the compressions of the highly informative segments are lossless and the less information segments are lossy. The results are furnished here [Table – 5].

TABLE V
COMPRESSION RATIO

Dataset Item	Compression Ratio
Dataset Item - 1	88.73
Dataset Item - 2	88.74
Dataset Item - 3	88.73
Dataset Item - 4	88.73
Dataset Item - 5	88.72
Dataset Item - 6	88.72
Dataset Item - 7	88.75
Dataset Item - 8	88.76
Dataset Item - 9	88.74
Dataset Item - 10	88.76
Dataset Item - 11	88.72

Dataset Item - 12	88.73
Dataset Item - 13	88.75
Dataset Item - 14	88.76
Dataset Item - 15	88.77
Dataset Item - 16	88.76

The results are analysed graphically here [Fig – 11].

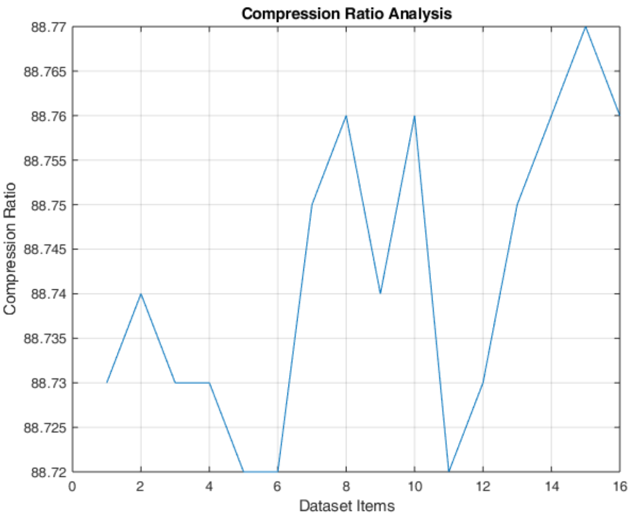


Fig. 11 Compression Ratio

The compression ratio is notable in case of any medical imaging framework and considering no loss of information

VIII. CONCLUSION

The medical image processing is the primary need for the professionals, researchers and the industry. The effective processing methods can automate many manual processes of the healthcare industry for disease detection, prediction, classification and pre-medications. The manual processes are bound to the human errors and time consuming. Thus, this work proposes a new framework for reduction of storage cost by introducing a medical image compression method with high compression ratio and low information loss. This proposed framework and algorithm is successful in making the automated medical image processing domain. An improved space for further researchers and adaptation of automation is done in medical industry.

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