RESEARCH ARTICLE

SAMRIDDHI Volume 15, Issue 1, 2023 Print ISSN: 2229-7111 Online ISSN: 2454-5767

Multidimensional Data Cube for Deciding on the Optimum Compression Method of Medical Images

Sumathy Y S, Sweeti, Tejaswini S*

Department of Medical Electronics Engineering, M S Ramaiah Institute of Technology, Bangalore-560054, Karnataka, India

Abstract

Storage needs in medical industry are increasing by 20-25% year after year. This poses a very serious challenge in the storage and transmission of images. Be it PACS or Cloud, the cost involved in per gigabytes (GB) data storage is very high. Compression is predominantly the solution which decreases the amount of storage and manpower. In order to automatically compress the images depending on the modality and the anatomy, it is very important to find the optimum compression method which gives very good compression and at the same time retaining its quality. Therefore in order to help the physicians or the radiologists to choose the best combination, we have come up with a cube structure.

SAMRIDDHI : A Journal of Physical Sciences, Engineering and Technology (2023); DOI: 10.18090/samriddhi.v15i01.40

Introduction

An effort has been made to investigate, evaluate and analyze the effects of compression on the size and quality of the image using popular compression algorithms. Compression ratios obtained when anatomy specific CT, MRI images are compressed using different methods and wavelets are tabulated in Table1 and the test images are shown in Fig 1

To decide on the best possible combination which helps in reduction of storage space and cost and also taking into account the quality of the compressed image, it is required to compare the huge tabulated data set. This is a tedious job. Therefore in this research an effort has been made to use Multidimensional Data Cube for Deciding on the Optimum Compression Method of Medical Images.

Methodology

Multidimensional Data Cube

Decision support system users often see data in the form of data cubes. Data Cube is a one of the popular structure which is widely used to represent multidimensional data along some measure of interest. Each dimension represents some attribute in the database and the cells in the data cube represent the measure of interest. For example, they could contain a count for the number of times that attribute combination occurs in the database, or the minimum, maximum, sum or average value of some attribute. Queries are performed on the cube to retrieve decision support information.

Corresponding Author: Tejaswini S, Department of Medical Electronics Engineering, M S Ramaiah Institute of Technology, Bangalore-560054, Karnataka, India

How to cite this article: Sumathy, Y.S., Sweeti, Tejaswini, S. (2023). Multidimensional Data Cube for Deciding on the Optimum Compression Method of Medical Images. *SAMRIDDHI : A Journal of Physical Sciences, Engineering and Technology,* 15(1), 226-229.

Source of support: Nil

Conflict of interest: None

Deciding on the Optimum Compression Method

The data cube shown in Fig 2 is a 3- dimensional structure representing medical images, different algorithms and wavelet filters. The cells in the data cube represent the CR's (refer Table 1) obtained by compressing anatomy and modality specific medical images using different methods and wavelets. This is shown in Fig 3. The cube can be used to retrieve information within the database to find is to which method in combination of different filters gives the best CR.

From the data cube, it is very easy compare the results and decide on the optimum condition. In this example SPIHT (highlighted) method gives consistent CR values and can be chosen as the optimum method.

Deciding on the Optimum Compression Ratio

The values in the data cell shown in Fig 4 represents CRs

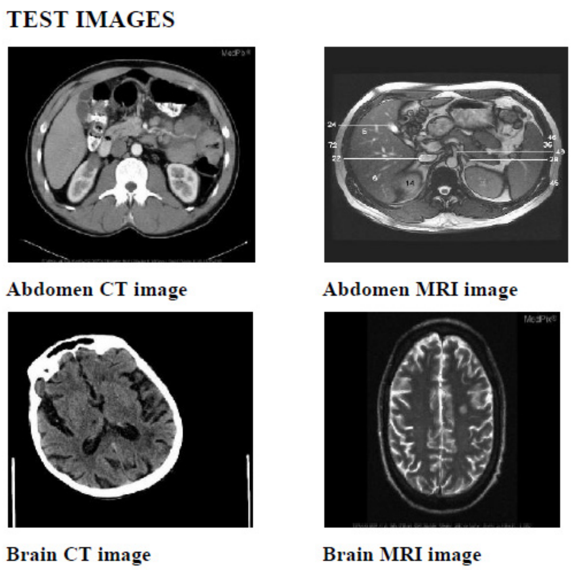

Figure 1: Test Images

Table 1: CR analysis for anatomy specific CT and MRI images

Images	*Wavelets*	*EZW*	*SPIHT*	*STW*	*WDR*
CT Brain	Haar	59.25	64.83	60.65	52.7
	Db7	68.2	64.32	58.5	63.65
	Bior 4.4	70.4	65.91	60.97	66.35
	Sym 8	69	64.83	59.5	64.7
CT Abdomen	Haar	41.6	50.5	42.8	31.48
	Db7	62.77	53.71	45.6	57.98
	Bior 4.4	65.6	56	49.01	61.31
	Sym 8	63.87	54.8	47.2	59.26
MRI Brain	Haar	54.66	57.7	53.04	46.96
	Db7	75.69	62.85	59.17	73.3
	Bior 4.4	64.51	64.3	61.27	59.92
	Sym 8	76.7	63.84	60.3	74.42
MRI Abdomen	Haar	45.7	52.4	45.53	35.88
	Db7	66.62	57.17	51.84	62.34
	Bior 4.4	68.57	58.53	53.73	64.8
	Sym 8	67.68	57.72	52.76	63.63

achieved at different encoding loops when anatomy and modality specific medical images were compressed using SPIHT method in combination with different wavelets (Table 1).

From the data cube analysis, it can be stated that a spectrum of CR can be achieved at varying encoding loops. The acceptable CR's considered are 90%, 85%, 75%, 65% and 55%. This selection is arrived by considering the average of compression ratios (highlighted yellow row) across encoding loops. From the data cube, the maximum and minimum CRs obtained for particular image can be found. The maximum CR obtained is highlighted with red circle and minimum compression obtained is highlighted with blue circle. For all the images the maximum compression ratio is around 90% and the minimum compression ratio for CT Brain image is around 65%, for CT Abdomen is 50%, for MRI Bain is 58% and for MRI Abdomen is around 50%. From the data cube analysis it can be said that brain images can be compressed at a higher CR ratio than abdomen images.

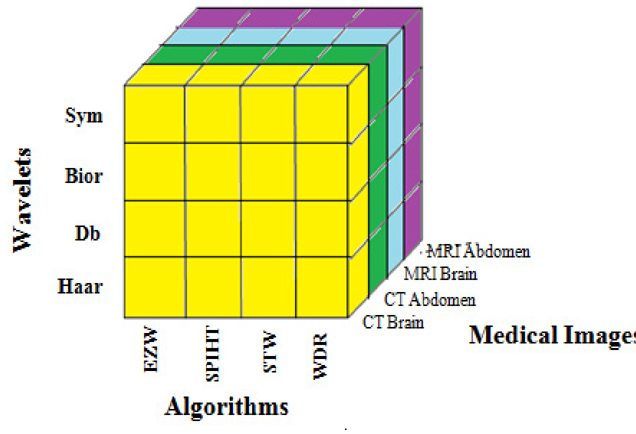

Fig 2: Front View of the Data Cube

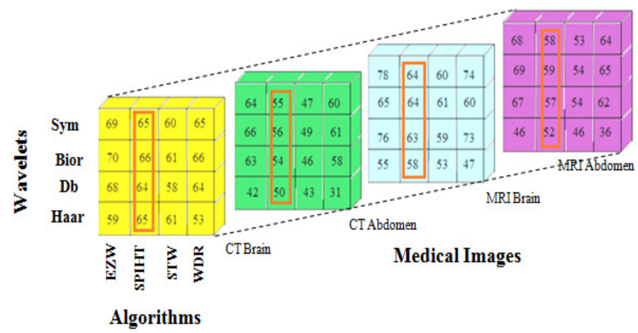

Fig 3: Entire View of the Data Cube

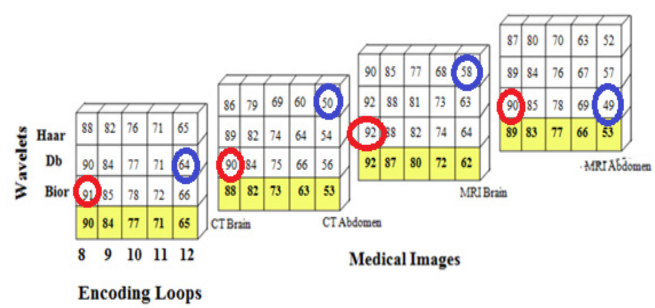

Fig 4: Data Cube for Decision of CR

Table 2: Reduction in Storage Requirements with Increase in CR

Compression Ratio	*CT Image Data*		*MRI Image Data*	
	Avg. MB per study	*GB per year*	*Avg. MB per study*	*GB per year*
Uncompressed	52	1040	39	195
55% (2.2:1)	23.4	473	17.55	89
65% (2.8:1)	18.2	372	13.65	70
75% (4:1)	13	260	9.75	49
80% (5:1)	10.4	208	7.8	39
85% (6.7:1)	7.8	155	5.85	29
90% (10:1)	5.2	104	3.9	19.5

Table 3: Storage Requirements in a Medium- Sized Hospital

Modality	*Percent of studies*	*Uncompressed*	
		Avg. MB per study	*GB per year*
Angiography	3	15	45
CR and DR	64	42	2688
CT	20	52	1040
MR	5	39	195
Nuclear Medicine	3	1.3	3.9
Ultrasound	5	18	90
Total TB per 100,000 studies		4.1 TB	

Considering the different CRs, the amount of reduction that can be achieved in the image data storage is shown in Table 2. Depending on the storage requirements, choice of particular CR can be made and thereby reducing the storage cost.

From the Table 2, it is very evident that, as the CR increases there is decrease in the storage requirements be it average megabytes per study or gigabytes per year. The uncompressed data is obtained from Table 3. The CR is user defined and is based on the storage requirements. Higher CR can be chosen but at the cost of quality of the image.

Conclusion

Ttaking into account the average images produced in a medium sized hospital from major imaging modalities, the annual storage requirements is about 4TB [Table 3]. With improved resolution and the increasing number of scans, the storage required is further increasing exponentially. Storage and management of such large data is a challenge and also the other limitations add to it. Even a small reduction in the storage requirements makes space for storage of some more images, thereby reducing the storage cost. Thus cuboid representation of the data helps in easy selection of the compression ratio.

References

[1] Ravi Varma Dandu, **"**Storage media for computers in radiology"**,** Indian J Radiology Imaging. Nov 2008, 18(4): 287–289.

[2] Colang J E, Johnston J N, "PACS storage technology update: Holographic storage", http://www.ahraonline.org/AM/Downloads/OnlineEd/2006MayJune2.pdf;

[3] Retention and Storage of Images and Radiological Patient Data – The Royal College of Radiologists, London 2008

[4] Shini S G, Tony Thomas, and K Chithraranjan, "Cloud Based Medical Image Exchange-Security Challenges", Procedia Engineering, Vol. 38, 2012, pp 3454-3461

[5] Don Dennison and Kinson Ho, "Informatics Challenges—Lossy Compression in Medical Imaging", J Digit Imaging (2014) 27:287–291

[6] Kofidis E, "Wavelet-based medical image compression", Future Generation Computer Systems, Elsevier Science Publishers. Amsterdam, Vol. 15, No. 2, 11 March 1999, pp 223-243.

[7] Medical Image Sharing and Management Drives Collaborative Care: Overcoming Fragmentation to Create Unity - A Frost & Sullivan White Paper Storage Management.https://www.emc.com/collateral/analyst- reports/4_fs_wp_medical_image_sharing_021012_mc_print.pdf

[8] *Govindji R. Jankharia,* Commentary - Radiology in India: The Next Decade, Indian J Radiol Imaging. Aug 2008; 18(3): pp 189–191.

[9] TCO Comparison –Iron Mountain, 2011.

[10] Steve G Langer, Challenges for Data Storage in medical Imaging", Journal of Digital Imaging, Apr 2011, 24(2), pp. 203–207.

[11] "Indian PACS Market – Changing Dynamics" Anurag Dubey, Industry Analyst, Healthcare Practice, Frost & Sullivan

[12] Avinash et al. Purpose-driven data representation and usage for medical images United States Patent US 7,970,203 B2 Jun. 28, 2011 https://patentimages.storage.googleapis.com/59/4a/7f/3289f34c552fbd/US7970203.pdf

[13] Fu H, Jin Z, et al. (2003). Picture archiving and communication system in China: the development, *Indian J Radiology Imaging. 2008 Aug; 18(3): 189–191.*

[14] www.cio.com/article/2860072/healthcare/how-cios-can-prepare-for-healthcare-data-tsunami.html

[15] Soumya Sen and Nabendu Chaki, "Optimal Space and Time Complexity Analysis on the Lattice of Cuboids Using Galois Connections for Data Warehousing", https://www.researchgate.net/publication/232619489

[16] eContent, MSIT 116C, Data Warehousing and Data Mining.pdf
[17] Puja Bharti, "Comparative Analysis of Image Compression Techniques: A Case Study on Medical Images", 2009 International Conference on Advances in Recent Technologies in Communication and Computing, 10/2009
[18] Kogure Y, Matsuoka H, Akutagawa M, Shimada Y and Kinouchi Y, " The Applications of Remote Patient Monitoring System using a Java-enabled 3G Mobile Phone", IFMBE Proceedings WC 2006, World Congress on Medical Physics and Biomedical Engineering, Vol. 14, pp.3522-3525, (2006)