Available online at www.sciencedirect.com
SCIENCE DIRECT•
Mathematical and Computer Modelling 41 (2005) 1325–1339
MATHEMATICAL AND COMPUTER MODELLING
www.elsevier.com/locate/mcm

Progressive Transmission of Images: Adaptive Best Strategies

I. BAEZA, J. VILLANUEVA-OLLER AND R. J. VILLANUEVA
Instituto de Matemática Multidisciplinar
Valencia, Spain

A. G. LAW
Department of Clinical Neurosciences
University of Calgary
Alberta, Canada

(Received January 2004; accepted February 2004)

Abstract—Two progressive transmission procedures that are adaptive are developed, for any 3-D image which is composed from n, disjoint regions of any type. Each of the two is responsive to both the particular reconstruction process employed at the recipient node and the detail within the image. If some of the regions have already been transmitted, a next from among the remainder can be selected through an individually-best remaining region (IBRR) or a globally-best remaining region (GBRR) strategy. For each, its ordering template need to be determined only once, *a priori*. GBRR's sequence information requires considerably more CPU resources to obtain, but the resulting progressive technique can be more effective, as is illustrated using a test set consisting of 93 CT slices (resolution 256 × 256) of a human head. An algorithm is developed for automatically decomposing any 3-D images into regions that are not of the "parallel plane slicing" variety. Then, Experiment 2 illustrates effectiveness of IBRR (and hence, also GBRR) sequencing for a CT phantom, when this non-parallel plane decomposition replaces a parallel plane decomposition of it. Both IBRR and GBRR generalize to the setting of 4-D data sets generated from dynamic MR imaging, for example. © 2005 Elsevier Ltd. All rights reserved.

Keywords—Progressive transmission of images, Adaptive transmission, 3-D images.

INTRODUCTION

In the evolving fields of medical imaging, problems of manipulating, processing, or analyzing large data sets grow in complexity. Routinely now, CT scans can generate 50 MB of data, for one patient in one examination, representing a single 3-D digital replication of a part of his or her body. With emerging 3-D ultrasound and dynamic MRI (3-D objects changing over time) technologies, data sets of 500 MB or more can be created, and accompanying problems for storage, querying, compression or transmission grow in complexity as well as size. For network transmission, there are two major classes of algorithms to first compress (i.e., reduce the size of) a data set: *lossless*, where redundancies in the data are removed insofar as is practical, and *lossy*,

This research has been supported by the Spanish Ministerio de Ciencia y Tecnología (Secretaria de Estado de Universidades e Investigacion), and FEDER grant TIC2002-02249, and by a Canadian NSERC Grant 171126-2001.

0895-7177/05/$ - see front matter Typeset by $\mathcal{A}_\mathcal{M}\mathcal{S}$-TEX
doi:10.1016/j.mcm.2004.02.035

produces as output, a progressive transmission of it or a numerically-optimized progressive transmission of it, respectively. The second procedure provides an alternative of regions which are not derived simply from slicings with parallel planes. All algorithms and techniques generalize to a 4-D setting.

REFERENCES

1. E. Defez, A.G. Law, J. Villanueva-Oller and R.J. Villanueva, Matrix cubic splines for progressive transmission of images, *Journal of Mathematical Imaging and Vision* **23** (1), 41–53, (2002).
2. E. Defez, A.G. Law, J. Villanueva-Oller and R.J. Villanueva, Matrix Newton interpolation and progressive 3-D imaging: PC-based computation, *Mathl. Comput. Modelling* **35** (3/4), 303–322, (2002).
3. W. Schroeder and K. Martin, *The VTK User's Guide*, Kitware Inc., (1999).
4. W. Schroeder, K. Martin and B. Lorensen, *The Visualization Toolkit. An Object-Oriented Approach to Graphics*, Prentice-Hall, (1997).
5. H. Zhu, R.A. Brown, R.J. Villanueva, J. Villanueva-Oller, M.L. Lauzon, J.R. Mitchell and A.G. Law, Progressive imaging: S-transform order, *Journal of the Australian Mathematical Society B Series* (to appear).
6. Y.-S. Kim and W.-Y. Kim, Reversible decorrelation method for progressive transmission of 3-D medical image, *IEEE Trans. Medical Imaging* **17** (3), 383–394, (1998).
7. E. Kofidis, N. Kolokotronis, A. Vassilarakou, S. Theodoridis and D. Cavouras, Wavelet-based medical image compression, *Future Generation Computer Systems* **15**, 223–243, (1999).
8. E. Defez, A. Hervás, A.G. Law, J. Villanueva-Oller and R.J. Villanueva, Progressive transmission of images: PC-based computations using orthogonal matrix polynomials, *Mathl. Comput. Modelling* **32** (10), 1125–1140, (2000).
9. TCL Developer Xchange, `http://www.scriptics.com`.
10. R.C. González and R.E. Woods, *Digital Image Processing*, Addison-Wesley, New York, (1993).
11. S.G. Mallat, A theory for multiresolution signal decomposition: The wavelet representation, *IEEE Trans. PAMI* **11** (7), 84–95, (1980).
12. T. Sigitani, Y. Iiguni and H. Maeda, Progressive cross-section display of 3-D medical images, *Phys. Med. Biol.* **44** (6), 1565–1577, (1999).
13. E.J. Stollnitz, T.D. DeRose and D.H. Salesin, Wavelets for computer graphics: A primer, Part I, *IEEE Computer Graphics and Applications* **15** (3), 76–84, (1995).
14. K. Tzou, Progressive image transmission: A review and comparison of techniques, *Opt. Eng.* **26**, 581–589, (1987).
15. W. Wrazidlo, H.J. Brambs, W. Lederer, S. Schneider, B. Geiger and C. Fischer, An alternative method of three-dimensional reconstruction from two-dimensional CT and MR data sets, *Med. Biol. Eng. Comput.* **38** (2), 140–149, (2000).