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Lossy Image Compression

Domain Decomposition-Based Algorithms

Springer

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Preface

Image data compression is concerned with minimization of the number of information carrying units used to represent an image. Image compression schemes can be divided into two broad classes: lossless compression schemes and lossy compression schemes. Lossless compression techniques, as their name implies aim at exact reconstruction and involve no loss of information. Lossy compression techniques accept some loss of information, therefore images compressed using a lossy technique cannot be reconstructed exactly. The distortion in the image caused by lossy compression may be imperceptible to humans and we obtain much higher compression ratios than is possible with lossless compression. Lossy compression scheme can be further divided into three major categories: 1. Transform coding, 2. Fractal image compression, and 3. Domain Decomposition. Joint Photographic Expert Group (JPEG), JPEG2000, Binary Tree Triangular Coding (BTTC) etc. are the examples of lossy image compression methods. This book describes five new domain decomposition based lossy image compression algorithms, evaluation of their performance and their parallel implementation.

Organization of the book is as follows. Chapter 1 brings the subject matter into perspective and presents a historical review of image compression in moderate detail. Chapter 2 presents four new image compression algorithms namely, Three-triangle decomposition scheme, Six-triangle decomposition scheme, Nine-triangle decomposition scheme and 4. Delaunay Triangulation Scheme. Performance of these algorithms is evaluated using standard test images. The asymptotic time complexity of Three-, Six-, and Nine-triangle decomposition algorithms is the same: $O(nlogn)$ for coding and $\theta(n)$ for decoding. The time complexity of the Delaunay triangulation algorithm is $O(n^2logn)$ for coding and $O(nlogn)$ for decoding, where n is the number of pixels in the image.

Chapter 3 presents more domain decomposition algorithms using quality measures like Average Difference (AD), Entropy (H), Mean Squared Error (MSE) and a fuzzy geometry measure called Fuzzy Compactness (FC). All the partitioning methods discussed in this chapter execute in $O(nlogn)$ time for encoding and $\theta(n)$ time for decoding, where n is the number of pixels in the image.

Chapter 4 presents parallel version of domain decomposition algorithms on different architectures like Concurrent Read Exclusive Write (CREW) Parallel Random Access Machine (PRAM), Hypercube, 2-D Mesh, and Sparse Mesh. Time complexities of these algorithms are also derived. Implementation of the domain decomposition algorithm on Parallel Virtual Machine (PVM) environment using Master-Slave paradigm has been described. Parallel program profiles and speed up measurements are given.

Finally, concluding remarks and future research directions are discussed Chap. 5.

A comprehensive bibliography related to the field is included at the end.

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Contents

Symbols and Notations

A	Signed area of triangle
l_i	Edge length of a triangle
α_i	Signed altitudes of a triangle
r_i	Signed radius of an element
θ_i	Angle at vertex v_i of triangle
N_n	Number of nodes in triangular mesh
E_n	Number of edges in triangular mesh
T_n	Number of triangles in triangular mesh
$F(.)$	Original gray value of the image
$F'(.)$	Gray value of the reconstructed image
$G(.)$	Predicted gray value of the image using linear interpolation
L	List of leaves
M	Image size
H	Height of fuzzy set
W	Width of fuzzy set
L	Length of fuzzy set
B	Breadth of fuzzy set
A	Area of fuzzy set
P	Number of processors
O(.)	Asymptotic upper bound
Ω(.)	Asymptotic lower bound
Θ(.)	Asymptotic upper and lower bound

Abbreviations

AD	Average difference
BAS	Binary adaptive segmentation
BSP	Binary space partitioning
BTTC	Binary tree triangular coding
CQ	Correlation quality
CR	Compression ratio
CREW	Concurrent read and exclusive write
DCT	Discrete cosine transform
DFT	Discrete fourier transform
DWT	Discrete wavelet transform
FC	Fuzzy compactness
H	Entropy
ICT	Irreversible component transform
IF	Image fidelity
IOAC	Index of area coverage
JPEG	Joint photographic expert group
JPEG 2000	Joint photographic expert group 2000
LMSE	Laplacian mean square error
MD	Maximum difference
MSE	Mean square error
NAE	Normalized absolute error
NK	Normalized cross-correlation
NMSE	Normalized mean square error
PMSE	Peak mean square error
PRAM	Parallel random access machine
PSNR	Peak signal to noise ratio

PVM	Parallel virtual machine
RCT	Reversible component transform
SC	Structural content
SIC	Segmentation based image coding
SIMD	Single instruction multiple data
SPMD	Single program multiple data
WD	Weighted distance