Bi-Level Image Compression

EECE 545: Data Compression

by Dave Tompkins
Overview

• Introduction to Bi-Level Image Compression
• Existing Facsimile Standards:
  • G3 (MR)
  • G4 (MMR)
  • JBIG[1]
• New Bi-Level Standards:
  • JBIG2
Introduction: Meet Dave

Dave and his Mom:
Definition: Bi-Level

Multi-Level (Gray Scale) | Bi-Level (Black & White)

[Images of a girl in grayscale and a girl in bi-level]
Properties of Bi-Level Images

• Mostly High Frequency
• Often Very High Resolutions:
  • Computer Monitor: 96dpi
  • Fax Machine: 200dpi
    • 1 page fax (8.5” x 11” x 200dpi) $\sim=.5$ Meg
  • Laser Printer: 600dpi (1 page = 4.2 Megs)
  • High-End Printing Press: 1600dpi (30 Megs!)
• Will often contain text, halftoned images and line-art (graphs, equations, logos, etc.)
Existing Fax Standards

- T.4 (Group 3) MH (Modified Huffman): Huffman & Run-Length Encoding (RLE)

Code Lengths are based on statistics, not actual length

Codes are different for each colour

Codes are fixed, and never change
Existing Fax Standards

- T.6 (Group 4) MMR (Modified Modified Read): Huffman Coding & Modified RLE
  - 3 Different Modes
  - run lengths are relative to the previous line

**Diagram**

- Reference Line
- Current Line

**Modes**

- **Vertical mode:** \( |a_1 b_1| \leq 3 \)
- **Horizontal mode:**
- **Pass mode:** \( a_1 \) past \( b_2 \)
Existing Fax Standards

- **T.4 (Group 3)**
  - MH - Modified Huffman (and RLE)
  - MR - Modified Read
    - Uses information from previous line
    - Uses MH mode every k lines for error correction

- **T.6 (Group 4)**
  - MMR - Modified Modified Modified Read
    - Uses information from previous line
    - Assumes Error-Free Environment
Existing Fax Standards

- JBIG[1] (T.82 -- March, 1993)
- Joint Bi-Level Image Experts Group
  - Committee with Academic & Industrial members:
    - ISO (International organization of National Bodies)
    - ITU-T (Regulatory body of the United Nations)
- Arithmetic Coding (QM Coder)
- Context-based prediction
- Progressive Compression (Display)
Existing Fax Standards

• Standard JBIG1 Context:

• ? = Pixel to be coded
• A = Adaptive pixel (which can be moved)
• Example:

  = 17%

  = 83%
Existing Fax Standards

- **JBIG1**: Progressive Compression (Display)

- Standard defines how to reduce the image

- Predictive context uses information from previous resolution level

![Diagram showing progressive compression]

By Dave Tompkins
Existing Fax Standards

- Arithmetic Q Coder
  - Numerous variations: Q, QM, MQ
    - Used by JBIG[1], JPEG, JBIG2 & J2K
    - Different probability tables, byte markers, etc.

- Adaptive Coder
  - 16-bit Precision (32-bit C register)
  - Uses numerous Approximations:
    - Fixed Probability Table
    - No Multiplication
New Standards

- JBIG2 (T.88 -- February 2000)
- First “lossy” bi-level standard
- Supports Three basic coding modes:
  - Generic (MMR or JBIG[1]-like arithmetic)
  - Halftone
  - Text
- Image can be segmented into regions
  - Each region can be coded with a different method
Segmentation is performed on compound documents to detect different regions.
JBIG2 - Generic Coding

- The core coding method of JBIG2 has not changed that much from previous methods.
- There are two methods available in generic coding:
  - MMR (Group 4)
  - MQ Arithmetic Coding (similar to JBIG[1])

Larger contexts are available:
JBIG-2 Halftone Coding

- A halftone is coded as a multi-level image, along with a pattern and grid parameters.
- The decoder constructs the halftone from the multi-level image and the pattern.
- The multi-level image is coded as bi-level bit-planes, with the generic coder.
JBIG2 - Text Coding

- Each symbol is encoded in a dictionary with generic coding:
- And then, the image is constructed by adding images from the dictionary:

\[ \Delta y \]
\[ \Delta x \]

- The symbol ID and the (relative) co-ordinates are coded
JBIG2 - Text Coding

• In actual documents, many symbols are very similar -- often due to scanning or spacial quantization errors

• Lossy Coding: Hard Pattern Matching

• Lossless Coding: Soft Pattern Matching
JBIG2 - Soft Pattern Matching

• Soft Pattern Matching (refinement coding) is when a symbol is coded using a similar, previously coded symbol to provide additional context information.

Already coded: \( e \)

To be coded: \( e \)

\( x \)

\( ? \)